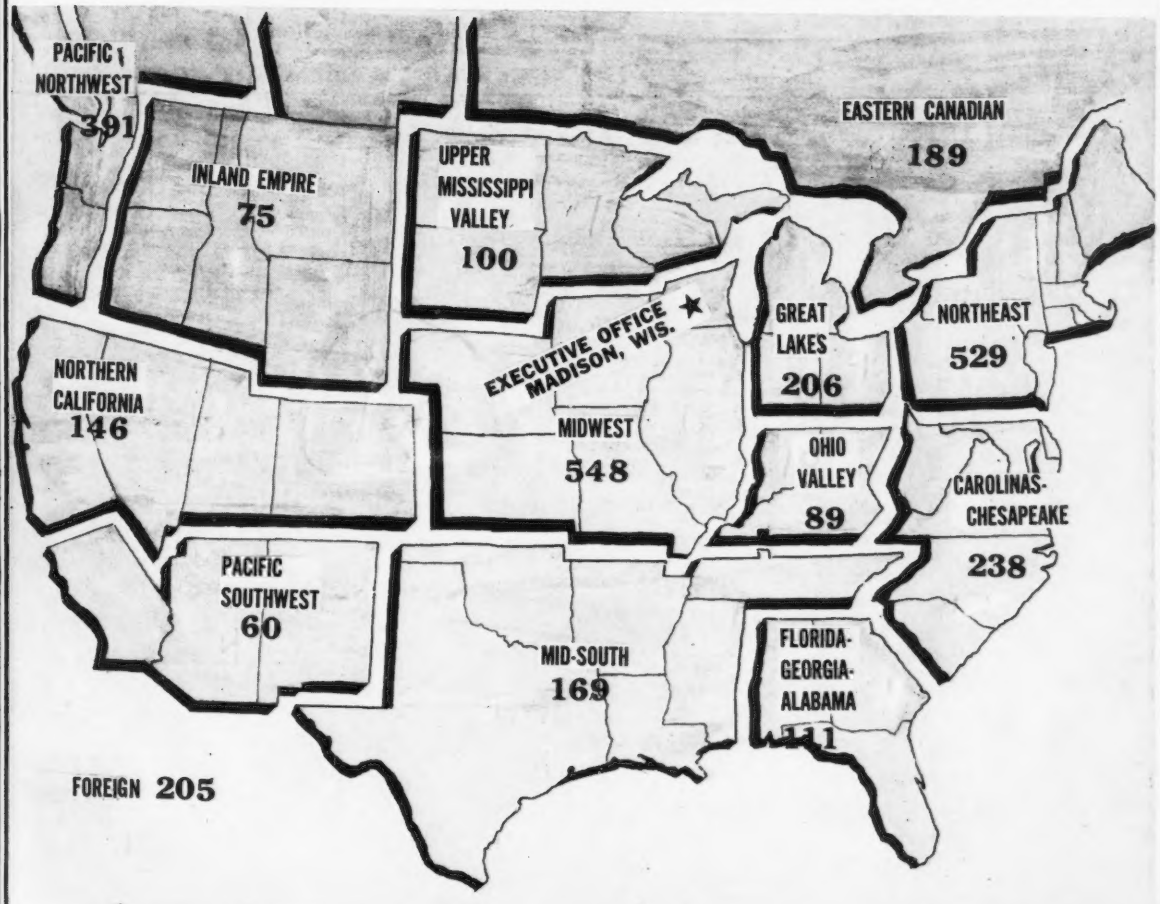
Forest Products Journal

1955 YEARBOOK



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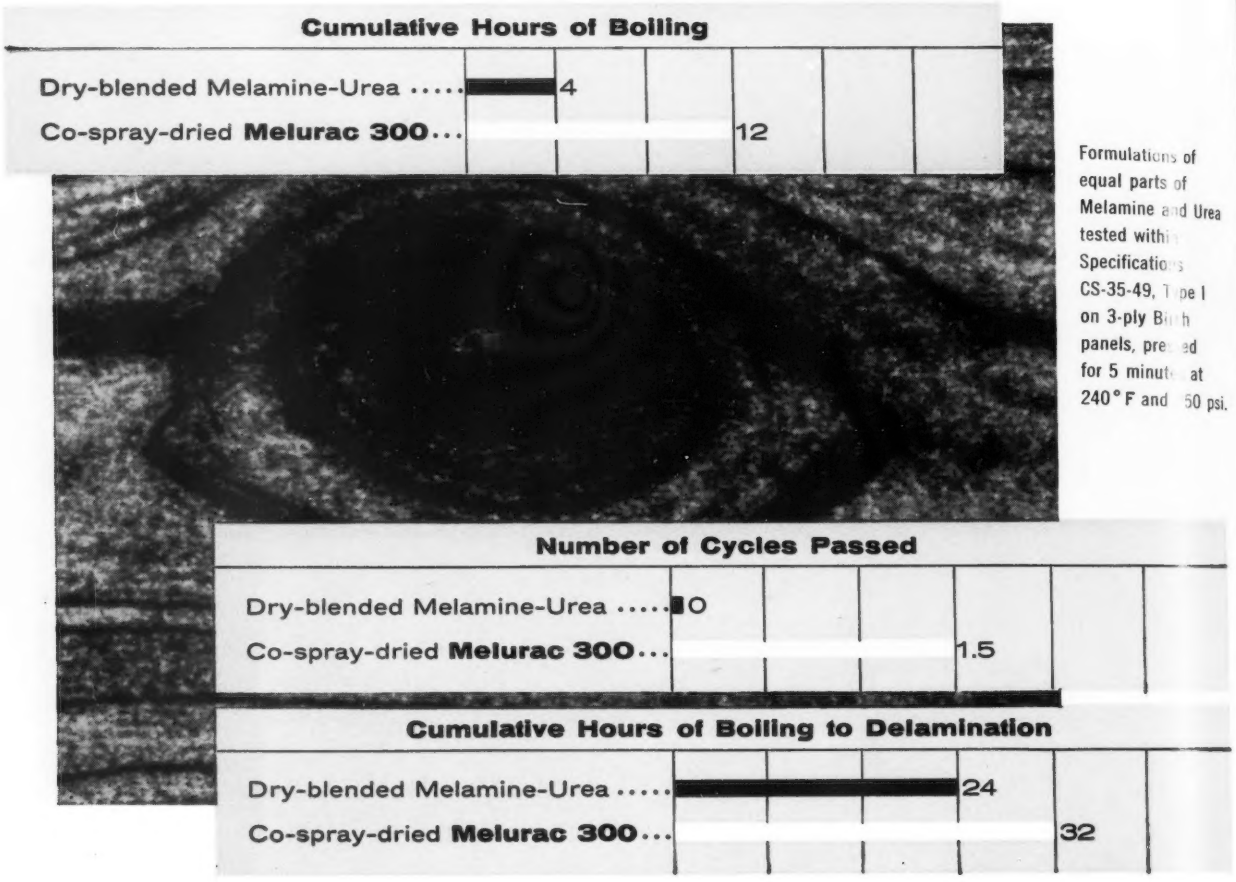

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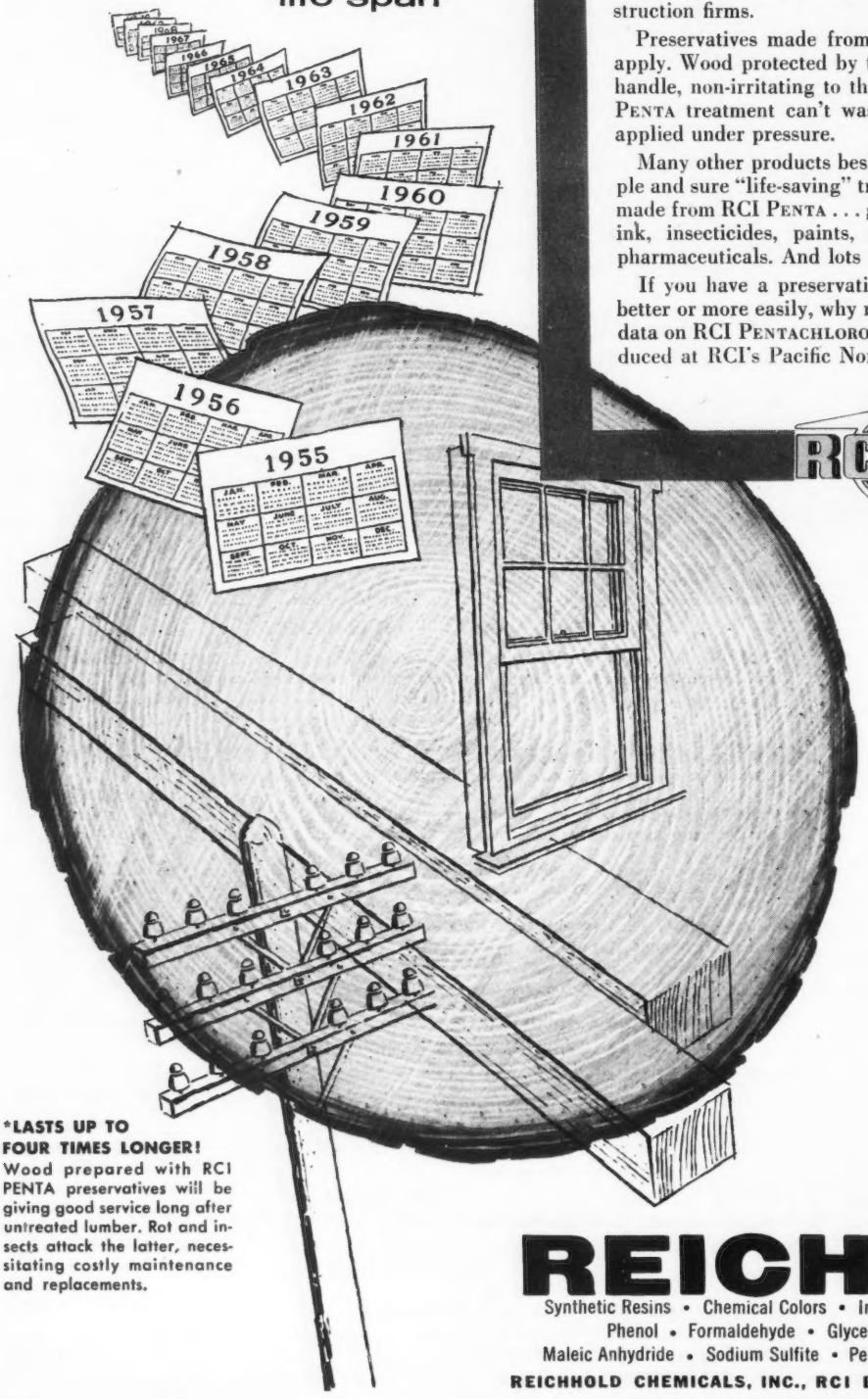
stretches lumber's life span*



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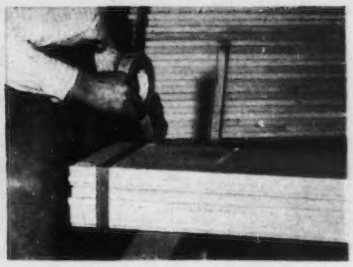

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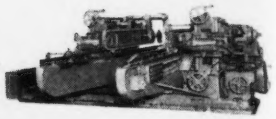

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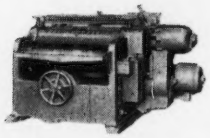

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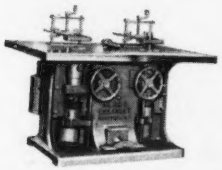

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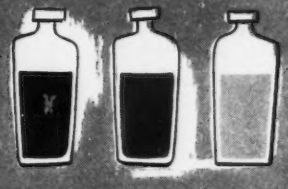

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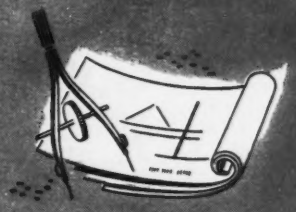

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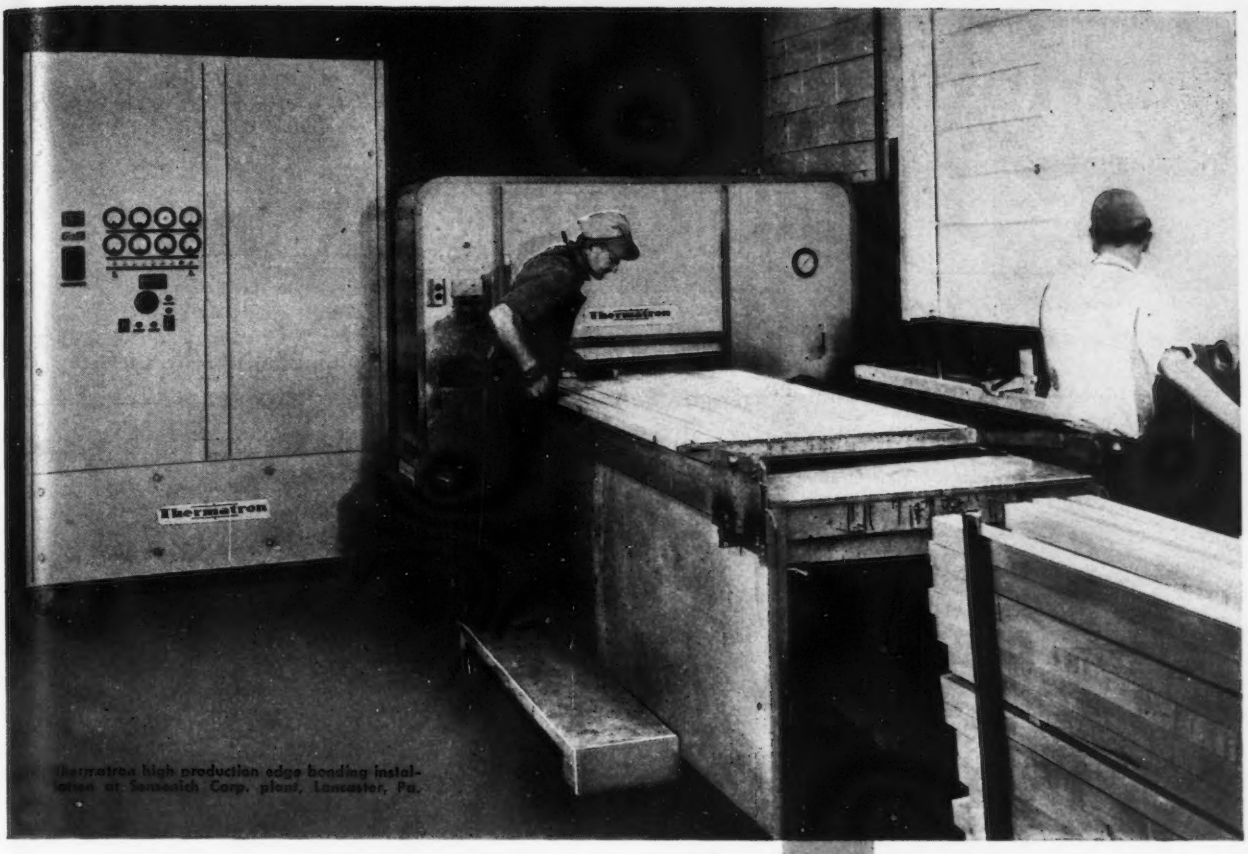

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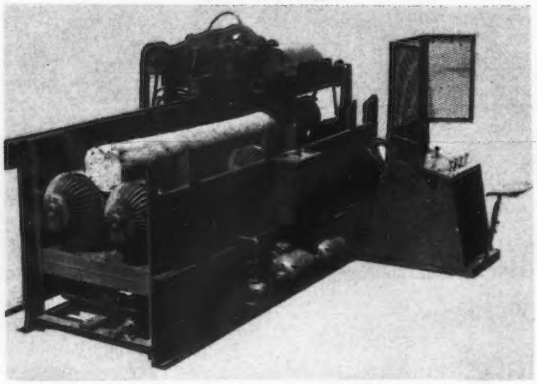

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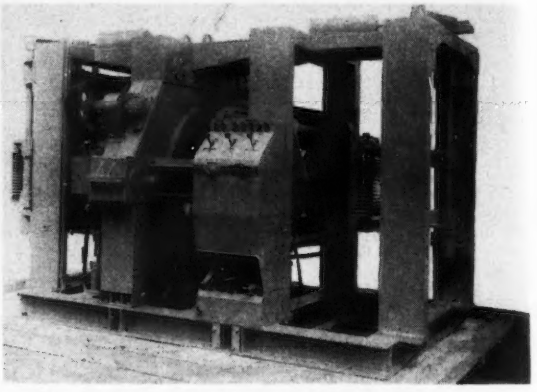

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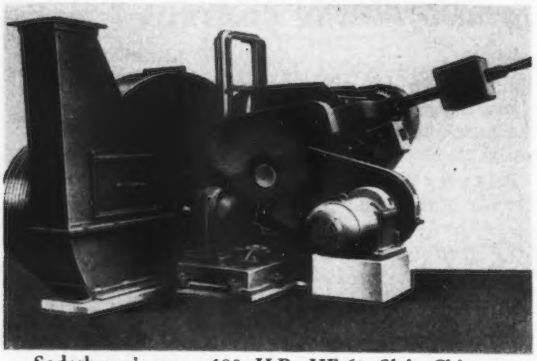

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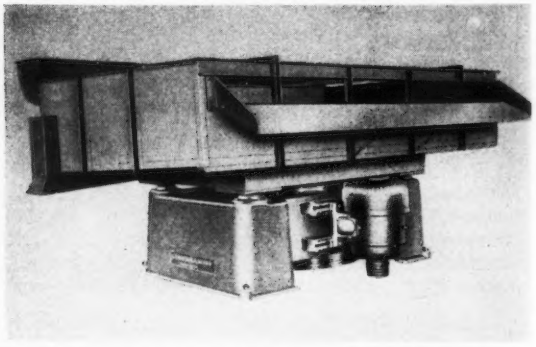

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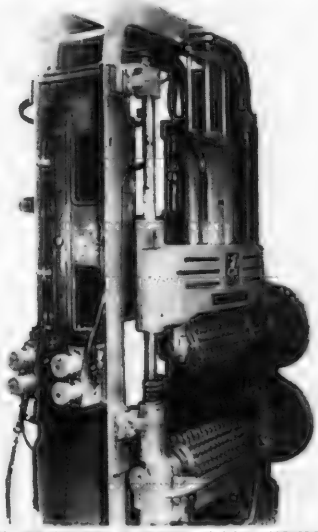

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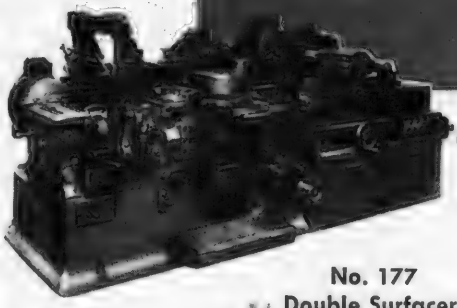

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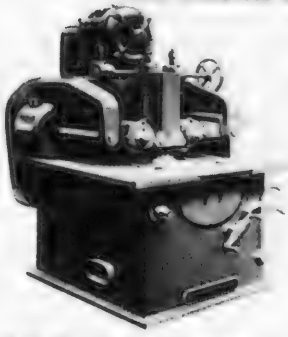

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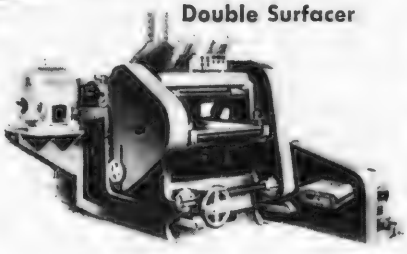

A20 Matcher

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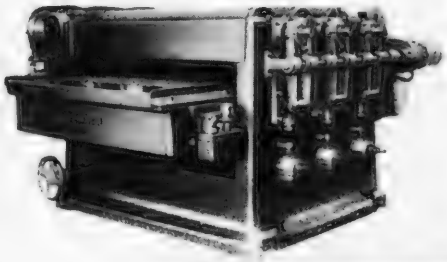
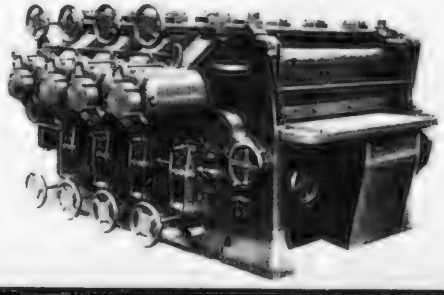
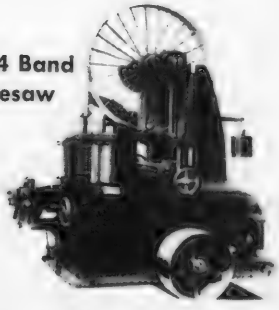


S800 Roll-Feed Sander



V54 Band Resaw

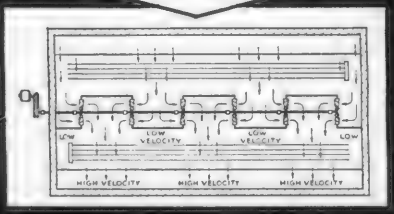


Yates-American

BELOIT, WISCONSIN

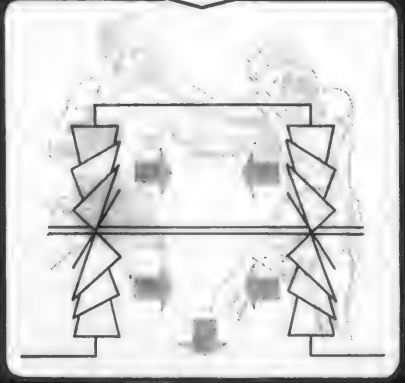
Branch Offices: CHICAGO, ILL. • HIGH POINT, N. C. • MEMPHIS, TENN. • PORTLAND, ORE.

STANDARD Switched from this Out-of-Date Kiln Design in 1937



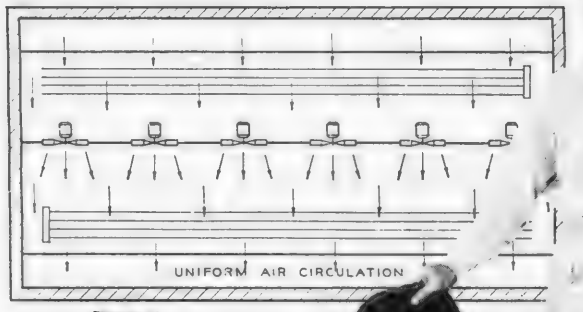
COSTLY OLD-FASHIONED KILN with line-shaft driven fans placed, *opposed in pairs*, at right angles to the direction of air flow proved to be an outmoded method of driving and an inefficient method of circulating air. It caused *indirect* cross circulation which resulted in greater horsepower consumption due to line-shaft drag, deflecting baffles, and fans blowing into each other. Using this design, baffles or ducts were required to deflect the air 90° which resulted in considerable *increases* in power consumption and *decreases* in fan delivery.

Because When Kiln Fans Fight Each Other— You're the Loser!



OPPOSED IN PAIRS, kiln fans blow into each other—losing you money in increased power and maintenance costs, less uniform air circulation. That's why the modern Standard Dry Kiln with direct uniform cross re-circulation (without end drift) is so efficient and economical. It has direct ball-bearing driven fans which are *properly* placed, facing the direction of air flow through the lumber. Result: Low-cost operation, more uniform air circulation!

HERE ARE THE FACTS!



STANDARD'S

DIRECT CROSS-FLOW DRY KILNS ARE THE MOST EFFICIENT, MOST ECONOMICAL YOU CAN INSTALL!

OFFICIAL CERTIFIED TESTS made in accordance with the code of the National Association of Fan Manufacturers, and the American Society of Heating & Ventilating Engineers and "Rated in accordance with the Standard Test Code by the Texas Engineering Experiment Station" (branch of the University of Texas), show that Standard Dry Kiln Company fans 36″ in diameter, 2-blade, run by Standard's direct connected motor at 1168 RPM against .10″ static pressure, produces 12,400 cubic feet of air per minute at 1.47 brake horsepower under standard air conditions. (Power requirements decrease as the temperature increases. Approximately 20% reduction results at kiln temperatures of 180 degrees F.)

These official tests confirm repeated tests made by our fan manufacturer and ourselves in actual kiln conditions and in our own wind tunnel.

This same fan has been used since 1937 in thousands of installations, and has proven itself in our kilns doing the highest quality drying of both green and air-seasoned lumber.

Standard's up-to-date direct ball bearing driven fans eliminate the power consuming penalties and upkeep of long shafts. Our modern Class H motors and wiring, today's standard throughout the motor industry for temperatures up to 350 degrees and 100% humidity, are used. These efficient, automatically reversible motors feature silicone greased ball bearings requiring attention only once every two or three years.

NOTE: Free air flow direct crosswise, no right angle turns, no fans blowing against one another.

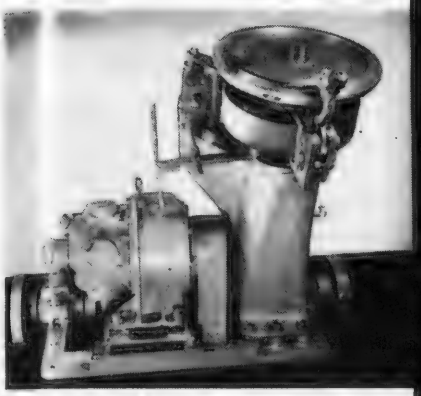
Today, more than ever before, Standard's theories of kiln design are proven where it counts—in the installation, in customer satisfaction, in repeat orders!

Manufacturers of Internal Fan Kilns

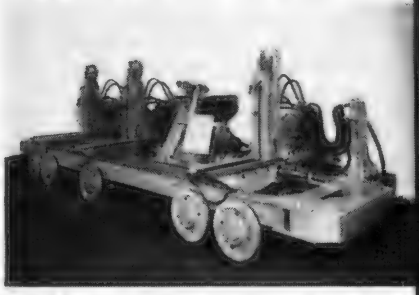
STANDARD
Engineers and Manufacturers Since 1887
DRY KILN COMPANY

P. O. BOX 5708....INDIANAPOLIS 21, IND.

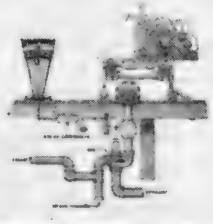
New Filer & Stowell Head Rig Machinery



AIR MOTOR SET WORKS — *Now preferred* as the most accurate setting and fastest receding set works. Rugged, simple construction eliminates costly repair. Easy to convert present set works to Filer & Stowell Air Motor Drive Set works. Write for bulletin #301.



AIR DOG CARRIAGES — Only Filer & Stowell Air Dog Carriages have the "Dual Movement", which eliminates miscutting by pulling the dogged logs back firmly against the head blocks. No faster dogging mechanism exists than Filer & Stowell inside the knee *Air Dogs* with top and center teeth.



SHOT GUN CARRIAGE FEEDS — Proven on more installations to be the *fastest and least costly drive* for sawmill carriages to get more lines per minute. Equipped with all the latest safety devices, these guns may be powered by steam or air. Find why smart sawmill operators are going back to this time proven method of driving Log Carriages. Write for Bulletin #303.

Now . . . increase production of better lumber at lowest cost. Filer & Stowell brings you the most accurate and durable Head Rig Equipment available, with the greatest capacity for more lines per minute.

To eliminate losses from "downtime", the *headache* of all mill men, Filer & Stowell *Head Rig* Machinery is recommended *the world over.*

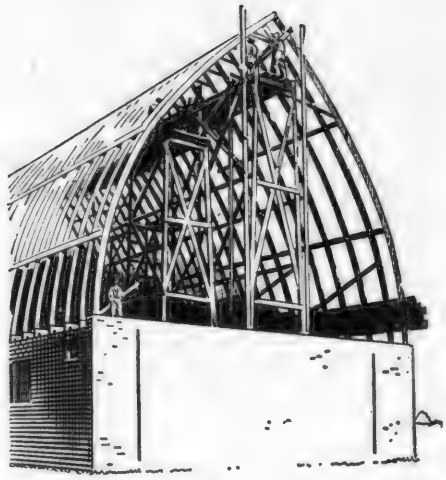
BAND MILLS — Only Filer & Stowell Band Mills have *all* the features needed to fulfill the desire of sawmill operators for the *most sensitive* and *durable* Band Mills. Ask for bulletin #300.

World's largest builders of sawmill machinery since 1856

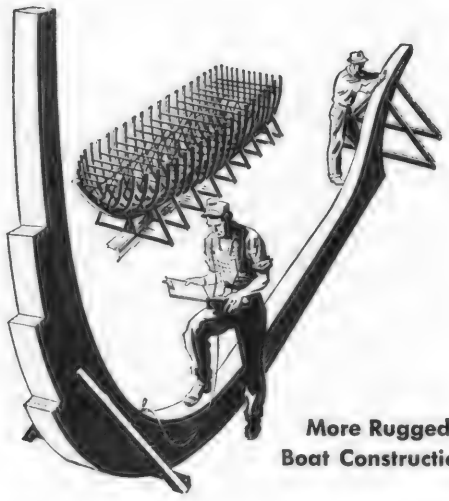
THE FILER & STOWELL CO.

147 E. Becher Street • Milwaukee 7, Wisconsin

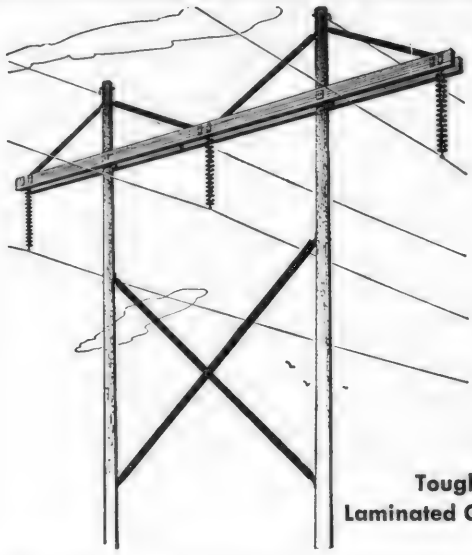
Sturdier Prefabrication Panels



Stronger Barn Rafters



More Rugged Boat Construction



Tougher Laminated Crossarms

Good properties of Penacolite Resorcinol Adhesives make them just right for the types of wood bonding jobs shown here. And the woods they bond *stay* bonded in spite of age or long exposure.

Penacolite bonds are completely waterproof, and remain as strong as the woods they join through all kinds of temperature changes. Furthermore, they withstand the shrinking and swelling of wood due to rain, sun, heat or cold, and are unaffected by exposure to greases, oils and most solvents.

Write us for information on Penacolite Adhesives. Our free, illustrated booklet gives complete details on these and *many* other applications. Koppers Company, Inc., Chemical Division, Dept. FP-105, Pittsburgh 19, Pennsylvania.

...And all are more durable because they are bonded with PENACOLITE® ADHESIVES

KOPPERS®

PENACOLITE® RESORCINOL ADHESIVES

The original waterproof, room-temperature-setting adhesives

FPRS COMPANY SUPPORTING MEMBERS

ALABAMA
W. T. Smith Lumber Co., Chapman

ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Mountain Pine
Southern Lumber Co., Warren

CALIFORNIA
California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
Ivory Pine Co., Dinuba
National Wood Treating Corp., Oroville
Philadelphia Quartz Co. of California, Berkeley
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
Winton Lumber Co., Martell
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

ILLINOIS
The Dean Company, Chicago
General Electric, Illinois Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin–Williams Co., Chicago
Steger Furniture Mfg. Co., Steger

INDIANA
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
The Wood-Worker & Veneers and Plywood, Indianapolis

IOWA
Curtis Co. Inc., Clinton

MARYLAND
J. I. Wells, Salisbury

MASSACHUSETTS
Draper Corp., Hopedale
Heywood–Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven

MINNESOTA
Mereen–Johnson Machine Co., Minneapolis
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis

MISSOURI
Monsanto Chemical Co., St. Louis

NEVADA
Vaughn Millwork Co., Reno

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
Georgia Pacific Plywood Co., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
U. S. Industries, Inc., New York
United States Plywood Corp., New York

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati
Moraine Box Company, Dayton

OREGON
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Blaw–Knox Company, Pittsburgh
Firth Sterling Corp., Pittsburgh
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer, Snyder County

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Wynnewood Products Co., Jacksonville

VERMONT
Fyles & Rice Co., Inc., Bethel

WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long–Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

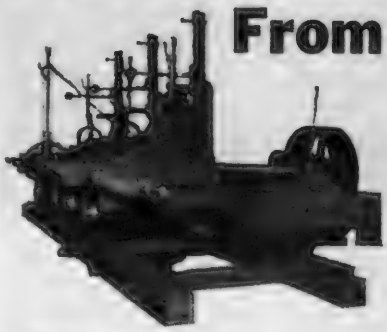
WISCONSIN
The Buckstaff Co., Oshkosh
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
British Columbia Lbr. Mfrs. Assn., Vancouver, B. C.
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
The Knight Mfg. & Lbr. Co. Ltd., Meaford, Ontario
MacMillan & Bloedel Limited, Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont

ENTERPRISE

From FOREST



to FINISHED PRODUCT

MODELS 21 and 34
SAW MILLS

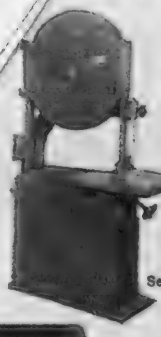
Built to withstand rugged service with continued accuracy, fast cutting and economical operation. Enterprise has been building machinery for over 75 years and our engineers have continued to incorporate all the latest advancements and improved designs in our standard sawmills. Special mills built to your individual requirements, related sawmill machinery and complete layout plans are available. Write for Bulletin 201.

36 in.
BAND SAWS

Especially designed to perform multiple sawing operations under heavy production schedules, with speed, accuracy and low operating costs. Principal features include:

- Massive construction
- Ball bearing guides
- Handwheel tilt table
- 16 or 23 in. under guide
- Models for cutting wood—metal—plastics burlap—paper—rubber

Send for Bulletin 205—NOW



Model P-24
PLANER

A heavy duty, precision built single surfacer designed to produce a fine finish on a variety of planing jobs. Costly extra operations can be eliminated by obtaining a quality finish cut first on a Crescent Planer.

Join the many users, in pattern shops, manual training schools, furniture factories, and other industrial plants who have discovered that fast-high speed planing with Crescent means low cost end products. For complete details of Models P-18 and P-24 Planers, write for free Bulletin 204.

THE ENTERPRISE COMPANY
COLUMBIANA, OHIO

AT THE JOHN WIDDICOMB CO. OF GRAND RAPIDS

Chairs and extension table are graceful and light in construction, yet built for lasting beauty. Dowel joints are permanently bonded with WOOD-LOK, National's cold run, ready-for-use resin glue.

Strength for Modern Simplicity comes from WOOD-LOK

WOOD-LOK produces handling bonds in as little as 15 minutes. It is used for doweling, blocking and gluing, mortise and tenon.

WOOD-LOK prevents chilled joints by allowing 5-7 minutes open assembly time. Production is speeded by automatic air pressure case clamp.

WOOD-LOK simplifies gluing of doweled butts and all other joints. It stays fluid in National's one-pint squeeze-applicator for fast, uniform spreading.

RESYNS® National ADHESIVES

WOOD-LOK vinyl co-polymer emulsion maintains maximum strength in dowel joints—as established by independent researchers.

SPECIAL OFFER! Write for 5 gallons of WOOD-LOK and a complimentary glue applicator—*on a trial and approval basis.*

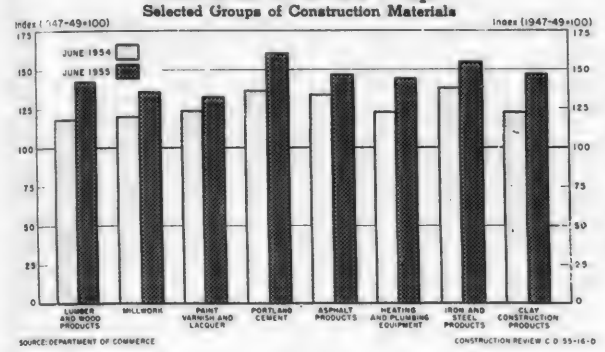
NATIONAL ADHESIVES. Woodworking Department JF (Resin Division), 270 Madison Ave., New York 16 • 3641 So. Washtenaw Ave., Chicago 32 • 735 Battery St., San Francisco 11 • 1511-23 So. Main St., High Point, N. C.

FPRS NEWS-DIGEST

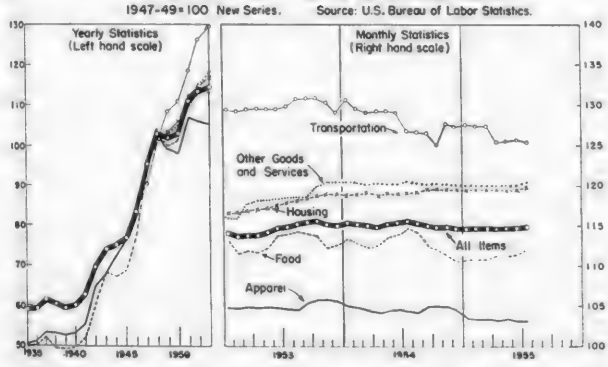
Volume 5 OCTOBER, 1955 Number 10

GRAPHIC TRENDS

Indexes of Materials Output
Selected Groups of Construction Materials



COST OF LIVING INDEXES
1947-49=100 New Series. Source: U.S. Bureau of Labor Statistics.



WHOLESALE PRICE INDEX for building materials reached an all-time high of 125.7 in July, a rise of more than 5 points since July '54. Almost a third of year's increase occurred between June and July. Higher prices for steel materials were dominant influence, ranged from 6 to 10 per cent. Slight increases were noted for maple flooring and softwood lumber.

—U.S. Dept. of Commerce

NEW WEEKLY PRODUCTION RECORD may have been set by Douglas-fir plywood mills in week ending Sept. 17 when 102 million feet went through presses. Output this year to date is racing 38.2% ahead of '54. Estimates on year-end production tally range between 4½ and 5 billion feet.

—Veneer Newsletter

BUSINESS OUTLOOK

GREATEST PERIOD OF OPPORTUNITY ever experienced is in store for American business, predicts Robert Paxton, executive vice-president of General Electric Co. GE expects the present record high levl of business activity to continue through '56, and has geared its production and marketing facilities accordingly, Paxton said. Research and product development are vitally important to GE, Paxton pointed out. The electrical manufacturing industry spends 6% of gross sales on research and development (three times the general industry average) and is growing at three times the rate of American industry generally. New products developed through research have created 70,000 new jobs at General Electric since 1939.

—Milwaukee Journal, Sept. 26, 1955

CONSTRUCTION OUTLAYS continued at peak levels in August, totaling nearly $4 billion, and reached an all-time high of $27.1 billion for first eight months of '55. Private residential construction edged off, reflecting a downward trend in housing starts during preceding two months.

—Construction Review

BEST SCORE OF YEAR was chalked up in both output and shipments of face veneers in August. Face veneer activity this year has consistently topped '54 pace, still falls short of matching big performance of '53.

—Veneer Newsletter

RECORD BUSINESS VOLUME in '55 is foreseen by Southern Furniture Manufacturers Assoc. Shipments for first six months showed gain of 20 per cent over last year, and topped first seven months of '54 by 3.4 per cent.

Get YOUR MILL Inside This Circle of LOWER COSTS — GREATER PROFITS!

Small Or Large— Your Mill Can Benefit from A Moore Stacker–Drying–Unstacker System

Take your first step now—learn how the Moore System can profit your mill—Mail Coupon Today!

MOORE DRY KILN COMPANY
P. O. Box 4248, Jacksonville 1, Fla.

YES, I am interested in reducing costs of ☐ stacking, ☐ kiln drying, ☐ unstacking, ☐ feeding machines, ☐ moving kiln loads or packages, ☐ other _____

Send information and ☐ have representative call.

NAME _____

COMPANY _____

STREET _____

TOWN _____ STATE _____

FPRS News-Digest, Continued

Three-Day Program Set For North-Central Regional Meeting

Five technical sessions with industry leaders participating have been arranged for the FPRS North-Central Regional Meeting Nov. 15–17 in Chicago. The meeting, to be held at the Blackstone Hotel, is being sponsored by the Midwest, Great Lakes, and Upper Mississippi Valley Sections.

Industry men will discuss how to make most profitable use of chipboard and particle board in combination with other materials, basing their talks on their own firms' operations, at the opening FPRS session. Wayne C. Lewis, Midwest Section Chairman, will preside.

Stephen B. Preston, Great Lakes Section Chairman, will preside at the Tuesday afternoon session on Efficiency in Material Usage in Furniture Manufacture.

Panel on Stanford Report

Implications of the Stanford Report on Future Demand for Wood Products will occupy the entire day's program Nov. 16. Industry leaders will give their views of the meaning of the report to their business at the morning session. Floor discussion of the report is scheduled for the afternoon session, with the panelists answering questions which the report raises for various segments of the industry.

Concurrent morning sessions are scheduled for Nov. 17, to be followed by individual business meetings of the three sponsoring sections. Fred Loveland, Chairman of the Upper Mississippi Valley Section, will preside at the session on What's Ahead in Wood By-Products.

Dr. Herbert O. Fleischer of the U. S. Forest Products Lab, Chairman of the FPRS Veneer and Plywood Committee, will direct a session on Hardwood Plywood—Today and Tomorrow. The program will conclude with a tour of the World of Hardwoods exhibit at the Museum of Science and Industry on the afternoon of Nov. 17.

Presentation of a scroll to Weyerhaeuser Timber Co. in appreciation of their contribution to the industry in making the Stanford Report available will be a highlight of the Official Luncheon on Nov. 16. FPRS President Moss B. Christian will present the scroll, which will be accepted for the Weyerhaeuser Co. by Bernard L. Orell, vice-president, Weyerhaeuser Sales Co., St. Paul.

Philadelphia Quartz Co. Is Newest Supporting Member

Philadelphia Quartz Company of California, Berkeley, has become a FPRS Company Supporting Member, joining the growing list of firms helping the Society to promote the scientific progress of the forest products industry.

The California firm, established in 1917, is a subsidiary of the Philadelphia Quartz Co., Philadelphia, which is 125 years old this year. It has expanded to three plants since 1917—in Berkeley, South Gate, Calif., and Tacoma, Wash.

Principal products of the company are soluble silicates in various ratios and forms. Both sodium silicates and potassium silicates are produced. The liquid silicates are widely used as an adhesive component in plywood and paper-overlaid wood laminates.

Interesting uses of sodium silicate occur in such applications as peroxide bleaching of wood pulp. Epsom salt, another company product, is used in the peroxide bleaching operation to control oxygen release. Sodium sesquisilicate has also proved useful in removing pitch from dryer rolls.

R. E. WRIGHT

Roy E. Wright is the firm's designated representative to FPRS. He holds a B.Ch.E. degree from U. of Minnesota and was employed by General Mills, Inc., from 1942–46, doing research and development work on monosodium glutamate. In his present post, Wright works on research, development, and customer sales and service.

Officers of the newest FPRS Company Supporting Member are: Alfred W. Elkinton, president; C. L. Baker, F. W. Elkinton, and T. K. Cleveland, vice-presidents; W. C. James, Secretary-Treasurer; C. L. Baker, Assistant Secretary; and H. R. Bucklin, Assistant Treasurer.

Inland Empire Section Schedules Spokane Meeting

Members and guests from five states attended the Inland Empire Section Meeting August 4–5 in Butte, Mont., according to Chairman C. J. Warren. Guests included John D. Ritchie, Tacoma, Wash., Pacific Northwest Regional Member of the Executive Board.

Four papers were presented during the meeting, with field trips being made to the Butte mines, Anaconda smelter, and central timber yards of Anaconda Copper Co. The program was arranged by E. C. Wert, Vice-Chairman, and T. S. Veazey, Jr., Secretary-Treasurer. Speakers were: Carl A. Rasmussen, Western Pine Assoc.; Lawrence M. Randle, Acme Steel Co.; William E. Welch, Timber Structures, Inc.; and I. V. Anderson, U. S. Forest Service.

The Section Executive Committee named the following committees: nominating, L. V. Brown, chairman, Robert E. Jones, and J. H. Leuthold; program, E. C. Wert, chairman, and T. S. Veazey, Jr.; and membership, H. B. McKean, chairman, and H. Z. White.

The Davenport Hotel, Spokane, Washington, was selected as the site for the January 1956 meeting of the Section. Topics being considered for the agenda include: high-speed wood lamination, pulping, composition boards, prefabricated houses, building codes and insurance problems, and electronic sorting of bark from fiber.

(Continued on page 102-A)

Part of Berkeley plant and laboratories of Philadelphia Quartz Company of California, latest firm joining FPRS as Supporting Member.

What isn't in the glue counts, too.

You can't weigh reputation or experience, yet they are shipped with every order of glue you place. When you order adhesives from Rohm & Haas Company, you're ordering not only the dependable products of a major manufacturer, but also the practical experience which accompanies a quarter-century of making synthetic resin adhesives. Because of Rohm & Haas experience, you get smoothly-running gluing operations and, if you wish, first-rate, experienced, technical help with your bonding problems.

UFORMITE

Uformite 400 and Uformite 435—liquid urea-formaldehyde glues for hot and cold bonding. Drum or bulk shipment.

Uformite resins 500, 505, CB-552, and CB-553—powdered urea-formaldehyde resins, catalyzed and uncatalyzed, for hot and cold bonding.

Uformite JS-508—one-component glue for tapeless splicing.

AMBERLITE

Phenolic powder and liquid resorcinol glues for hot pressing and cold bonding.

TEGO RESIN FILM

Phenolic glue in film form for hot pressing fragile and thin veneer.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

UFORMITE *and* AMBERLITE *are trade-marks, Reg. U.S. Pat. Off. and in principal foreign countries.*

IMPORTANT FPRS DATES

Nov. 15–17: North Central Region Meeting, Blackstone Hotel, Chicago, Ill.

Nov. 17–18: FPRS Executive Board Meeting, Blackstone Hotel, Chicago, Ill.

Nov. 18–19: Florida–Georgia–Alabama Section Meeting, Gainesville, Fla.

Nov. 19: Northeast Extension Meeting, Laconia, N. H.

Jan. 1956: Inland Empire Section Meeting, Spokane, Washington

March 1–2, 1956: Eastern Canadian Section Annual Meeting, Toronto, Ontario

June 4–7, 1956: FPRS NATIONAL MEETING at Asheville, N. C.

June 24–27, 1957: FPRS NATIONAL MEETING at Buffalo, N. Y.

Time Passes—Competition Presses

IF YOU WERE TO ASK John Q. Public what single industry he considers as most typically representative of American free enterprise, I daresay he would answer, "Automotive, of course."

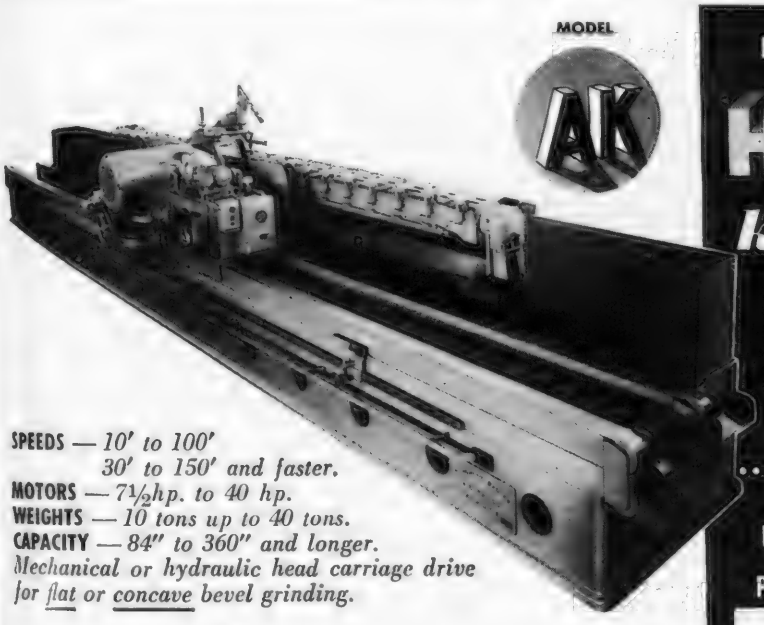
No other industry has had a more profound effect on our civilization than this giant that in 1955 expects to produce and sell more vehicles than in any previous year on record.

Paralleling its phenomenal growth has been the corresponding rise and influence of the Society of Automotive Engineers which this year is observing its 50th anniversary. It is interesting to note that some of the "growing pains" which our own Society has been undergoing for eight years were experienced by SAE a half century ago.

When SAE was formed in 1905, there was a great deal of skepticism going around in the then infant industry. It was widely doubted that experienced engineers would share their knowledge or discuss any of their trade secrets. Yet from the first meeting a pattern was established that is followed still: Speakers got up and talked about specific problems they had encountered and how they had gone about solving them — and the audience was free to question them. This cooperative attitude among the companies which made up the industry has been credited with hastening the arrival of our modern industrial age. It is a tradition which has continued for fifty years.

There is, as I see it, a great object lesson in this experience for our own adolescent Society. SAE, TAPPI, and other similar technical societies have proven beyond any measure of doubt that an industry progresses at an accelerated rate when it is backed up by an effective, thoroughly industry-sponsored technical organization. Today, FPRS has just passed the 3,000 mark in membership; yet it is attempting to adequately serve America's largest basic industry in terms of the number of individual plants — over 40,000 listed producing or manufacturing units. How and when are we going to attract to the cause the remaining 37,000-odd forest products companies? While time passes, competition presses. Our Society needs every salesman it can possibly inspire to help us reach our goal of a strong and effective society. Will you help us by inviting some business associate to become a part of this worthwhile movement?

—M. B. CHRISTIAN, *President*



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FOR ACCURACY — FINEST FINISHES

HANCHETT knife grinders

for the PULP AND PAPER INDUSTRIES

SPEEDS — *10′ to 100′ 30′ to 150′ and faster.*
MOTORS — *7½hp. to 40 hp.*
WEIGHTS — *10 tons up to 40 tons.*
CAPACITY — *84″ to 360″ and longer.*
Mechanical or hydraulic head carriage drive for flat or concave bevel grinding.

FOR GRINDING — HOG — BARKER PAPER TRIMMER AND DOCTOR BLADES

NEW MODEL SK-24 slitter knife grinder

FOR TOP — BOTTOM SLITTERS
CAPACITY 3″ TO 24″ DIAMETER
SEMI OR FULL AUTOMATIC
FINEST IN ACCURACY AND FINISH

Other Models. GK — **medium heavy duty** — *capacity 32″ to 184″*
DK — **normal production** — *capacity 32″ to 108″*

HANCHETT MANUFACTURING COMPANY
World's Largest Manufacturer of Knife Grinding and Saw Sharpening Machinery
MAIN OFFICE — Big Rapids, Michigan WEST COAST — Portland, Oregon

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19 REASONS

why these new 1956 AMF De Walt Power Saws

speed your cutting . . . lower your costs

MODEL GW-I WITH 10" SAW. With 1½ hp direct-drive motor, 120/240 voltage change switch. 10" saw blade cuts 3" deep, rips 26" wide, cross-cuts 16" wide on 1" stock. Steel base with welded carrying handles, carries through 30" door. Safety key switch, guard, anti-kickback device. Weighs only 183 lbs. **$382.50** complete delivered.

Larger sizes available

MODEL MB-F WITH 9" SAW. Portable, with new ¾ hp direct-drive motor, 120 V. 9" all-purpose saw blade cuts 2½" deep, rips 24" wide, cross-cuts 15" wide on 1" stock. Safety key switch, safety guard, and anti-kickback device. Weighs only 140 lbs. **$239** complete delivered.

Use your De Walt for framing, concrete forms, interior trim work, special built-ins . . . for *every* cutting need.

Join the thousands of builders who have found an AMF De Walt the *one modern, cost-saving* way to cut and finish lumber, in the shop or on the job.

Another AMF Product

DE WALT POWER TOOLS

The modern, versatile, job-proved De Walt Power Saw . . .

1. Does everything on the job, from framing to finishing.
2. Saves as much as 60% in power tool costs.
3. Instantly adjusts for any cut you want.
4. Gives machine-tool accuracy on all cuts—makes fitting easier, faster, finer.
5. Cuts lumber waste . . . salvages odd sizes.
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7. Saves as much as 90% in layout and marking time.
8. Reduces worker fatigue—operators *like* De Walt's easy handling.
9. Has big capacity in either size . . . with powerful, compact, direct-drive motor.
10. Complete in every way . . . sets up instantly on the job.
11. Conveniently lightweight . . . easily carries to any spot on the job site.
12. Gives modern, *straight-line* materials handling.
13. Has quick-set stops for all popular angle cuts.
14. Makes possible production-line cutting on the job.
15. Does special millwork . . . without mill costs.
16. Cuts all popular building materials including aluminum.
17. Has Underwriters' Laboratories, Inc. and Canadian Standards Association Approval for your extra protection.
18. Makes work go faster, more efficiently . . . one saw operator keeps a dozen or more carpenters busy nailing.
19. Custom-built, direct-drive motor minimizes maintenance.

Send for valuable Free Booklet on Job-Tested Methods for Cutting Building Costs.

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Please send me valuable Free 16-page Booklet on Job-Tested Methods for Cutting Building Costs.

☐ Please send handy Common Rafter Meter. I enclose 25c in coin

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Company _____

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Obsolete Machinery Erodes Profits[1]

RAY C. DU BRUCQ

President, Woodworking Machinery Manufacturers Association, and Special Washington Representative, Rockwell Manufacturing Co.

MACHINERY OBSOLESCENCE has become one of the big and important topics of industry—not on its own merits but rather on how to properly and economically dispose of it. There is no question about the need of this elimination in many of our industrial plants faced with competition from others who have already taken this step, and in many cases completely modernized.

Obsolete machinery is constantly paying for what should be—*but is not*—its replacement. It is paying through high production costs—costs that make it harder to meet competitive conditions of price and quality—costs that bring no profit returns and have no place in modern industry! Why do we have so much of it? Where does the responsibility *rest* for keeping up with the cost reducing replacement study? I say 'rest' in referring to an operation that is obsolete because its activity does not show. It is difficult to hide progress.

I was privileged to sit in recently at an annual meeting of plant managers of a fairly large, progressive organization with many scattered and diversified operations. An outstanding impression left with me was a criticism made by the Executive Vice-President. He seemed concerned because the past year had not developed what he considered sufficient requests for replacement equipment. He wanted to know if their operations had become so efficient that no replacements were required. He didn't believe they had, so insisted on a thorough re-study by each plant manager.

Replacements Must Be Justified

In this instance there was no *rest* even though the Executive had a suspicion that possibly there had been a 'catnap'. He revitalized plant management's activity and action was taken. This was not done merely to create capital expenditures, for no replacement that could not be fully justified would have been approved. That can be as foolhardy as obsolescence.

The most difficult selling job that is involved in machinery replacement is on the shoulders of the production manager. He is the one who must be prepared with actual facts and figures that make the procurement a *must*. Nothing less would justify a change. Top management, on the other hand, must be open to the data submitted and must also be sufficiently able to judge its merits. In short, proper replacement can only be made by an intelligent study of existing conditions, and the correction of weaknesses by a team that is qualified to make a true analysis.

Keeping up-to-date with all new developments, applying them to any operations that need improvement, and keeping posted on all extreme cost-laden operations which should be relieved, are top management's responsibilities. Obviously top management cannot and need not take this responsibility as a 'one-man' job. Good management is too busy for this. However, they can organize their team in a manner that will guarantee a continuous or even a periodic study of operations which will bring to light the costly obsolescence that is steadily eating away at the reason for being in business—profits.

In our highly competitive market, someone must pay for the usage of worn-out and out-of-date equipment. To cope with closely figured prices and still use yesterday's methods, some sacrifice must be made. If it is workmanship and material—the customer pays. If the manufacturer tries to maintain the quality—he must sacrifice profit. Either way, it shows there is a weakness in organization and perhaps a study should be made of obsolescence in management and staff.

Management Is Responsible

Too frequently management does a poor job of assigning responsibility or of following through to determine the results of their assignments. Either way they are at fault. Unless they keep their fingers on all conditions—(good or bad) that exist in their production lines, and act upon the sound recommendations that result from an organized analysis and study by a qualified staff, they are considered poor management.

Having visited many plants in various industries, I have developed my own so-called efficiency survey method. Perhaps it is not one that could be used to any advantage by others, but it leaves me with certain impressions and conclusions. Following up on it, I have not been too surprised when I would read or hear at some later date that "A" had folded and "M" had expanded.

Top management, though responsible, cannot be expected to personally see to it that all faults are corrected. They, alone, cannot maintain a clean, safe, and efficient productive plant. However, they must be certain that those assigned to the task perform for them.

The impressions and conclusions resulting from my plant visits do not reflect too much on the men in the plant, for they work and do as they are guided. The visits do leave with me an opinion of top management, however, and I have always felt better when that impression was good, even though it might be a competitor.

Many books have been written on the subject of obsolescence and more are probably being published. It is a never ceasing problem that rates constant attention. The proper solution of what to replace, when to replace it, and with what, is reached only through intelligent, organized study and usage of actual cost figures of the old and the presented (often proven) cost reducing potentials of the new.

In the woodworking equipment industry, the total volume of sales of replacements is much too low when compared with the volume of wood products sales. This is clearly evidenced when all industry figures of replacement are studied.

The products of the woodworking industry are in most instances items which are in use daily. They are things made of a natural beauty that must be retained, either through costly long man-hour finishing operations or by cost-reducing modern fine finishing machinery.

Why, When, and with What you should replace your obsolete machines is your problem. Study it!

The Author: Ray C. DuBrucq was Vice-President and General Manager of Crescent Machine Division, Rockwell Manufacturing Co., for more than 10 years. Since January 1951, he has been Special Washington Representative of the Rockwell Manufacturing Co. Mr. DuBrucq was previously associated with Mattison Greenlee Machine Companies, Yates-American Machine Co., and Wisconsin Knife Works.

Glues our salesmen sell with confidence

National Casein's salesmen — the glue technicians who work with you on your glue jobs — take this opportunity to salute National Casein's production men who are responsible for the consistently high and uniform quality of National Casein glues.

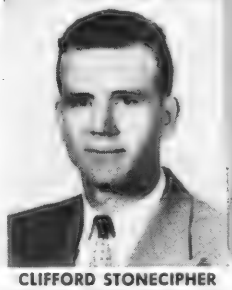
We know that not all glues are the same... that no single glue type or formula is adequate to every adhesive application. And we know that you — and we who represent them in your plant — can be confident that these men will deliver the glue your job requires — as you want it, when you want it — and in whatever quantity you want it — tank car, tank truck, drum or bag.

National Casein gives you a complete line of adhesives — resins, caseins, and vinyls — glues that measure up to the men who make them — glues you'll stick with because they stick for you.

NATIONAL CASEIN
By its Sales Representatives

FRED ATKINSON
Ohio, Michigan, Indiana. Experienced woodworker, glue technician. Long-time supt. of large Canadian plywood plant. War vet, Scout leader, civic worker.

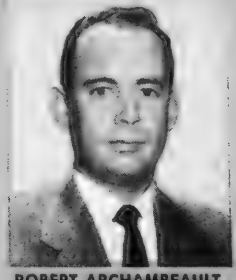
ARNO H. (MARTY) MARTEN
Wisconsin, Minnesota, Upper Michigan. An adhesive technician for 28 productive years. Dean of National Casein salesmen—and a true fisherman.



CLIFFORD STONECIPHER
Alabama, Florida, Georgia. Veteran woodworker with pattern making experience. Formerly machine dept. foreman in one of South's largest chair plants.

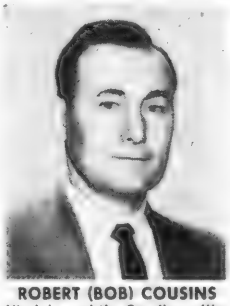
ROBERT E. (BOB) ALLEN
Tennessee, Kentucky, Illinois, Indiana and St. Louis. Adhesive sales technician. Former purchasing agent, World War II vet. Congenial and capable.

WARREN H. MELL
New England and New York City. Veteran of World War II. Lumber and woodworking technician. Cooperative, serious-minded, pleasant conversationalist.

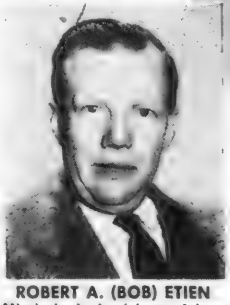


ROBERT ARCHAMBEAULT
Iowa, Nebraska, Northern Illinois, North Chicago. Adhesive sales technician. World War II pilot. Happy, genuinely-liked American of French descent.

O. B. (OBIE) DERR
Pennsylvania, West Virginia, New York, New Jersey. A sales technician for 20 successful years. Infectiously enthusiastic and entertaining.



ROBERT (BOB) COUSINS
Virginia and the Carolinas. War veteran and veteran adhesive technician. Intelligent conversationalist, popular with customers.



ROBERT A. (BOB) ETIEN
Mississippi, Louisiana, Arkansas, East Texas. Former woodworking plant manager. Red-haired, fun-loving sales veteran with "ZOOM!"

National Casein
601 W. 80th St., Chicago 20, Ill. • Broad and Fulton Sts., Riverton, N. J.

Ninth Annual National Meeting Big Success

FPRS' 1955 National Meeting marked a significant milestone in the Society's progress. First, we reached the 3000 mark in members and subscribers to the FOREST PRODUCTS JOURNAL. Second, FPRS' Subject Matter Committees vied favorably for attention and attendance with the Technical Program—a sign of their growing importance toward fulfillment of FPRS objectives. Third, FPRS press relations and resultant publicity set a new standard for future meetings. And finally, the fledgling FOREST PRODUCTS JOURNAL attained a measure of maturity as it was voted to increase its frequency to a monthly publication in 1956.

Over 600 Attendees

Attendance at the Ninth National Meeting reached 493 men and 109 ladies for the four days. The meetings were conducted June 21–24 in the Olympic Hotel, Seattle, Wash.

The Society's Executive Board actually was on deck for five days, meeting as a body on Monday, the day prior to the official opening. In addition to its regular duties, such as analysis of the budget and financial and membership status of the Society, the Board approved a recommendation of the Publications Committee that the Society's JOURNAL be issued monthly in 1956.

Registration started promptly at 1:00 P.M. on Monday and on the eve of the official opening of the meeting, Board Member R. D. Pauley counted a total of 292 men and 72 ladies either pre-registered or registered. The registration fee, $6 for members and $12 for non-members, included a set of abstracts of papers to be presented

Olympic Hotel—Meeting Headquarters.

and an invitation to the traditional Suppliers Paul Bunyan Potlatch.

The National Meeting was officially opened at Session I on Tuesday morning by FPRS President L. J. Carr, who welcomed the hundreds of registrants from the United States, Canada, and many parts of the world.

Greetings from Gov. Langlie

Honorable Arthur B. Langlie, Governor of the State of Washington, sent his official greetings:

"It is a pleasure indeed to express good wishes on behalf of the people of Washington to guests from all over the nation as well as foreign lands here for the Ninth Annual National Convention of the Forest Products Research Society.

"We are honored that you have chosen our forested state for your convention headquarters and look forward to the opportunity of extending every measure of hospitality to make your convention a memorable success.

"Forest products research has great meaning in the State of Washington where the people derive an annual income approaching one billion dollars from the wealth of our forests. The development of huge lumber mills, a pulp industry, plywood and shingle manufacture, chemical production and the countless allied industries have been synonymous with the rapid growth of the Pacific Northwest. Every step of scientific research unfolds for us the great potential of our woodlands. For your contributions to the economy and progress of this area, of the nation and of the world, we express our appreciation.

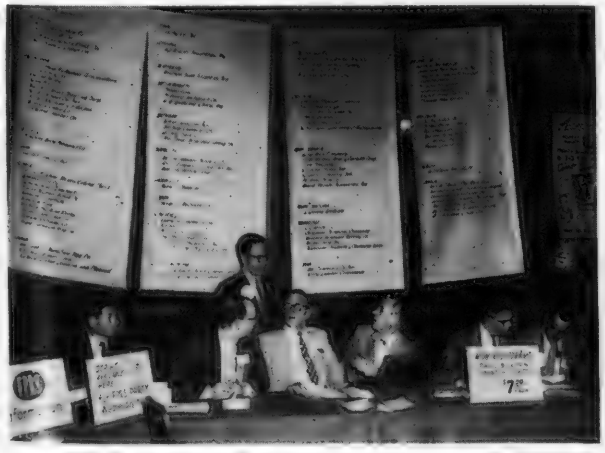
"We hope that as many of you as possible, after your convention has concluded, may stay on for a longer visit here in the Evergreen State and take advantage of some of the magnificent and scenic facilities for rest and recreation."

Alan Pomeroy, Mayor of Seattle, sent his greetings:

"In a very few years the entire outlook for the future of Forest Products has been reversed. "Cut out and get out" policies, with ever-lessening timber reserves, are gone. Present policies insure an ample sustained yield.

"The marriage of the technical laboratory with production skills of modern logging has already given birth to wood derivatives and by-products which were undreamed of a few years ago.

"The work of your group in developing new products and processes has turned the wood products picture from dismal gloom to one of brightest hope for the future of our most important natural resource. Such achieve-



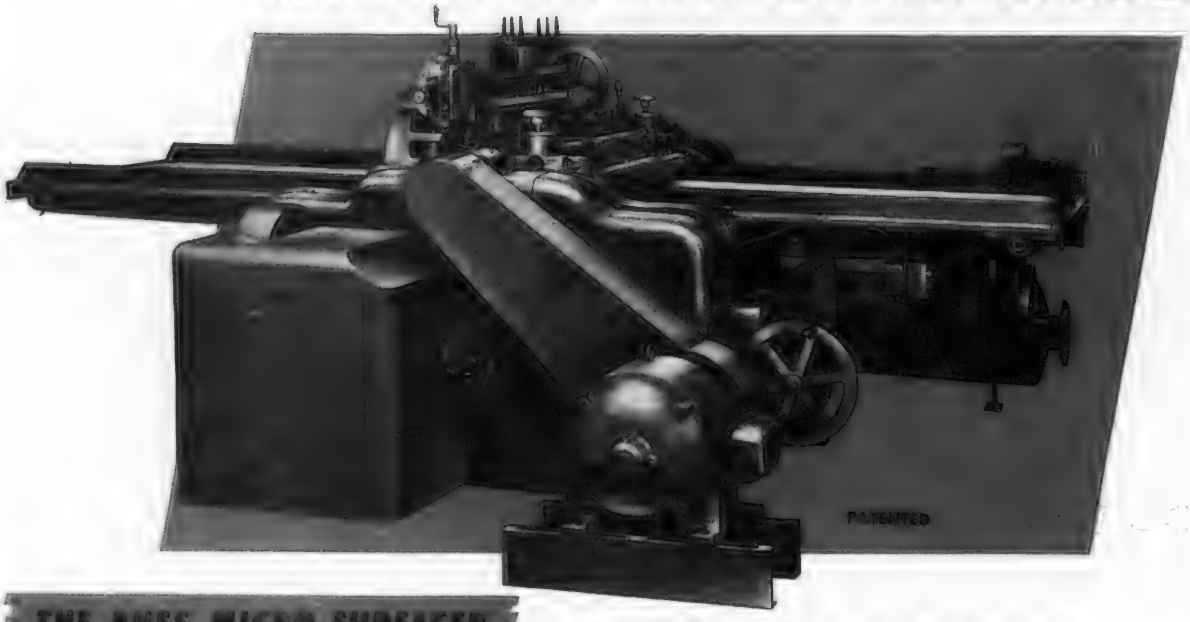
FPRS SUPPORTING MEMBER LIST formed backdrop for registration desk at Ninth National Meeting. Standing is Fred R. Armbruster, arrangements chairman. Seated, (left to right), are: Glenn Face; Thomas W. Secrest; Harold R. Evans, registration and tickets chairman; John D. Ritchie, general chairman; R. D. Pauley, treasurer and finance chairman; and Keith Binder, entertainment co-chairman.

FUTURE OUTLOOK for wood industry was discussed at press conference arranged by Perry Culp, Jr. (head of table), National Meeting Publicity Chairman. Around table, clockwise from foreground, are: FPRS President Moss B. Christian, Chicago Mill and Lumber Co.; B. Schulman, TIME magazine; C. C. Heritage, Weyerhaeuser Timber Co.; Dr. E. G. Locke, U. S. Forest Products Lab.; Culp; F. H. Snyder, consultant; W. H. Rambo, consultant. Also participating but not in photo were R. L. Hiller, American Cyanamid Co., new Executive Board member; and R. E. Shreck, Union Lumber Co., retiring Board member.

BUSS

The MICRO-SURFACER

A HIGH PRODUCTION MACHINE for PLANING HARDBOARD and OTHER VERY THIN MATERIALS



THE BUSS MICRO-SURFACER was developed to do what no other planer will do satisfactorily — to plane the very thin, highly flexible materials such as certain types of hardboard, presswood and related materials, rapidly and accurately. Close tolerances are easily maintained on this machine by means of a patented work platen which rigidly holds down the stock during the feeding and cutting operation. It employs our standard planer cutterhead with high speed steel knives operating at speeds up to 5,000 RPM. (Carboloy knives are available for applications involving abrasive materials). The MICRO-SURFACER can be furnished with in-feed and out-feed conveyors for rapid handling of stock and incorporates such exclusive BUSS features as: Chrome-plated wearing surfaces, semi-automatic control of lower rolls and pressure bar, one-shot lubrication, etc. Available in various width capacities up to 50".

The services of our engineering staff are available for consultation and working out details of all planer applications. Complete cooperation will be extended in any prospective application such as profile and contour work. Drop us a line.

BUSS
MACHINE WORKS
SINCE 1862

PLANER SPECIALISTS
292 EIGHTH AVE., HOLLAND, MICH.

LUNCHEON SPEAKER Stewart Holbrook (right), author and historian, was introduced by Past President Edward G. Locke.

ment makes you thrice welcome to Seattle."

In addition to the Technical Sessions, meetings were held by a number of the Society's Subject Matter Committees in such special fields as Wood Finishing, Glues, Logging, Sawmilling, Education and Wood Machining.

Overflow Crowd Hears Stewart Holbrook

On Tuesday noon over 475 persons, literally filling the huge Spanish Ballroom of the Olympic to overflowing, were well rewarded with an inspiring, homely, sometimes salty, address by Stewart Holbrook, former logger and nationally-famous author. Vermont-born, the only ex-lumberjack to lecture at Harvard University, and author of more than a dozen books on the Pacific Northwest, lumbering, and historical subjects, Holbrook viewed with some distaste the ruthless methods of timber barons of a by-gone era who "let daylight into the swamp, cutting a big swath from Bangor to Hoquiam". Holbrook pointed with pride to the mechanization of the logging and lumbering industry and to, more recently, the scientific development of new forest products to conserve a waning natural resource.

Complimenting FPRS, Holbrook added: "I don't know anything about research as such, but I know a whole lot about the need for it, and that is why you people are gathered here this week".

Annual Publishers' Awards Presented

Sharing the program with Mr. Holbrook were two award presentations. The 6th Annual Wood and Wood Products Awards were presented in behalf of Vance Publishing Company by Jack Koellisch, Manager of WOOD AND WOOD PRODUCTS Magazine. The Graduate Award of $350 and an inscribed certificate was presented to Ben A. Jayne, Yale School of Forestry, for his doctoral thesis, "A Non-Destructive Test of Glue Bond Quality in Laminated Wood" (see page 294). The Undergraduate Award of $150 and certificate was accepted by Professor R. W. Wellwood in behalf of Wallace Pearson, University of British Columbia, for his paper, "Reduction in Strength of Phenolic Resin Bonds of Douglas-fir Veneers Produced by Accelerated Weathering and Test Fence Exposure".

Other entries in the Graduate Division of Wood and Wood Products Award were: John W. Churchill, University of Michigan, "Effect of Time, Temperature, and Relative Humidity on the Relief of Casehardening Stresses"; C. Arthur Hart, North Carolina State College, "Effect of Temperature Variation on Results of the Cyclic Exposure Test for Glue Bond Durability"; Robert W. Kennedy, University of British Columbia, "Fungicidal Toxicity of Certain Extraneous Compounds of Douglas-Fir Wood"; Arno Schniewind, University of Michigan, "Effect of Wood Thicknesses on Hysteresis"; Peter Koch, University of Washington, "An Analysis of the Lumber Planing Process, Part I". The

ENGRAVED PLAQUE was presented to Past President L. J. Carr (right) by incoming President Moss B. Christian during Official Luncheon.

other Undergraduate Division entry was: Charles E. Goll, Colorado Agricultural and Mechanical College, "A Comparative Study of the Effectiveness of Brand Named Water Repellents".

The 2nd Annual Award of Merit citations, "In recognition of outstanding service in the promotion of wood and wood utilization", were presented in behalf of Hitchcock Publishing Company, publishers of WOOD WORKING DIGEST, by President R. C. Van Kampen to: V. Downing, Elliott Bay Lumber Co.; W. G. Soderquist, Hardwood Dimension Manufacturers Assn.; R. E. Mahaffey, West Coast Lumbermen's Assn.; W. H. Koepp, Michigan College of Mining & Technology; M. H. Nordquist and Donald Fuller, Architectural Woodwork Institute; William Hulbert, Jr., Western Red Cedar Lumber Assn.; Dr. E. A. Anderson, State University of New York College of Forestry; Gilbert R. Twynan, Mississippi Products Co.; H. I. Trowbridge, Wood Office Furniture Institute; Dependable Machine Co.; and The Borden Co.

The luncheon program was concluded with the presentation by the incoming president, Moss B. Chris-

AWARD OF MERIT citations in contest sponsored by Wood Working Digest were presented by R. C. VanKampen, President (left, back row). Plaques were accepted by (front row): V. Downing, Elliott Bay Lumber Co.; W. G. Soderquist, Hardwood Dimension Manufacturers Assoc.; R. E. Mahaffey, West Coast Lumbermens Assoc.; W. H. Koepp, Michigan College of Mining and Technology; M. H. Nordquist and Donald Fuller, Architectural Woodwork Institute; (back row): W. Hulbert, Jr., Western Red Cedar Lumber Assoc.; Dr. E. A. Anderson, State University of New York College of Forestry; Gilbert R. Twynan, Mississippi Products Co.; and H. I. Trowbridge, Wood Office Furniture Institute. Receiving awards but not represented in photo were: Dependable Machine Co. and The Borden Co.

WOOD AWARD winner in graduate division was Ben A. Jayne, right, candidate for Doctor of Forestry degree at Yale University. He received certificate and $350 check from Jack Koellisch, Editor and Manager, Wood and Wood Products Magazine.

PLYWOOD & LAMINATING ADHESIVES
HARDBOARD & WET-STRENGTH ADHESIVES

Research

- RESEARCH LEADERSHIP
- CUSTOM PRODUCTS
- QUALITY CONTROL
- PROMPT DELIVERY
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American-Marietta Co.
ADHESIVE, RESIN & CHEMICAL DIVISION
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PORTLAND, OREGON NEW WESTMINSTER, B.C.
CHICAGO, ILLINOIS

THE INDUSTRY BUILDER

SESSION I—COMPOSITION BOARD.

SESSION III—LOGGING AND MILLING.

tian, of a token of esteem from the membership to outgoing president, L. J. Carr. Mr. Carr received a richly gold-plated plaque containing an engraving of himself and the inscription: "In Appreciation . . . Hon. Lester J. Carr . . . As a director and officer of the international Forest Products Research Society's executive board since 1949, Mr. Carr has flown more than 75,000 miles at personal sacrifice, blazing new frontiers in forest products research, development, production, utilization and distribution."

On Tuesday and Wednesday afternoons, a number of informal tours were arranged for interested registrants to plants and institutions in and around Seattle. These included visits on Tuesday to:

Olympic Stained Products Company, Seattle—manufacturers of prestained shakes and siding, and a line of stains; U. S. Plywood Corporation, Seattle—manufacturers of Douglas-fir plywood and specialty plywood from Philippine mahogany, birch, knotty pine, and cedar; one of the largest slicing operations in the Pacific Northwest; U. of Washington, School of Forestry, Seattle—an opportunity to discuss problems of forestry education; F. S. Harmon Manufacturing Company, Tacoma—one of the larger furniture manufacturers in the Pacific Northwest. This company has made extensive use of statistical quality control methods as applied to furniture manufacturing.

Visits were arranged on Wednesday to: Weyerhaeuser Timber Company, Snoqualmie Falls—log barking, saw milling, lumber drying, planing, and the manufacture of a variety of products after whole wood fibers are taken from chips by the Asplund process; Elliott Bay Mill Company, Seattle—plywood and door manufacturer specializing in the use of Philippine mahogany and other exotic tropical woods.

On Tuesday evening an event of interest principally to past national officers of the Society, the First Annual Past Presidents' Dinner, was held at the Washington Athletic Club. The Society was honored to have present a distinguished array of past presidents dating back to 1947. In attendance either at the formal noon luncheon or evening affair were Honorary First Chairman Bror Grondal, 1947; Fred W. Gottschalk, 1948; George A. Garratt, 1949; Edward G. Locke, 1950; Roy M. Carter, 1952; Kenneth G. Chesley, 1953; and Robert D. Pauley, 1954. Former President James F. Hamilton, 1951, was unable to be present.

A social highlight of the meeting was the FPRS Party on Wednesday evening, preceded by a cocktail hour. The gala evening was attended by 438 guests and included a delightful dinner, a fast-moving five-act floor show, and dancing. A number of fortunate ladies came away with beautiful door prizes, gifts of the host Pacific Northwest Section.

New National Officers Announced

The Annual Business meeting was held on Thursday forenoon (see full report, page 31A). Newly-elected officers, board members, and the national nominating committee for 1956 were announced by the Chairman of the Tellers Committee, George W. Stanley, Jr., General Manager, Solar–Sturges Manufacturing Company, Melrose Park, Illinois.

Under the FPRS Constitution, Moss B. Christian, current President-Elect, automatically succeeded to the presidency. Elected to the office of President-Elect was R. H. Bescher, District Manager, Wood Preserving Division, Koppers Company, Pittsburgh, Pennsylvania. Elected Vice-President was Dr. Frank H. Kaufert, Director, School of Forestry, University of Minnesota, St. Paul. Elected North–Central Regional Board Member was Robert L. Hiller, Technical Representative, American Cyanamid Company, Chicago, Illinois. Elected Southwest Regional Board Member was Raymond H. Berry, Vice-President, Scott Lumber Co., Burney, Calif. Elected to serve on the 1956 National Nominating Committee were: Dr. James S. Bethel, N. C. State College, Raleigh; John B. Grantham, Oregon Forest Products Lab, Corvallis; Col. J. H. Jenkins, Forest Products Laboratories of Canada, Ottawa; and W. L. Lear, Crossett Lumber Co., Crossett, Ark.

Following the Business Meeting, members of the new Executive Board joined the Section Officers' Advisory Committee for their 5th annual joint luncheon and meeting. The purpose of this event is to provide an opportunity for the National Executive Board to sit down at a shirt-sleeve, problem-solution, work session with elected officials or their appointed alternates of FPRS' 13 Sections from coast to coast. (See complete report, page 67–A).

Suppliers Sponsor Paul Bunyan Potlatch

The social climax of the Ninth National Meeting was the festive Paul Bunyan Potlatch at Twanoh State Park

(Continued on page 53-A)

THREE FPRS CHIEFS installed in Northwest Indian tribe during Paul Bunyan Potlatch were: President Moss B. Christian, Past Presidents R. D. Pauley and L. J. Carr.

THERE ARE ALWAYS NEW USES FOR WEST COAST LUMBER

This striking "inside-outside" truss is one of the many interesting new uses of wood for home construction. Intended primarily to give a feeling of greater height in the living room, it also helps create a spacious, informal atmosphere. Outside, this truss application makes possible a post-free overhang for a protected patio and children's play area.

For freedom of expression, specify wood . . . the economical, ever-modern building material. For dependable lumber, specify the West Coast species . . . Douglas Fir, West Coast Hemlock, Western Red Cedar and Sitka Spruce.

WALTER GORDON
Architect, AIA

Graduated from Princeton and later took his M.F.A. there. Also studied at University of Paris, and at Yale University graduate school. Has designed numerous homes, many of which have been featured in national magazines.

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Minutes of FPRS Ninth Annual Business Meeting

THE NINTH ANNUAL Business Meeting of FPRS was called to order by President Lester J. Carr at 11:30 A.M., Thursday, June 23, 1955, in the Junior Ballroom of the Olympic Hotel. Seventy-five members were in attendance.

1. Minutes of 1954 Business Meeting

The preceding annual business meeting was held in Grand Rapids, Michigan, May 6, 1954. The Minutes were published in the October, 1954, JOURNAL. There were no corrections or additions suggested, and it was duly moved by Dr. George Garratt, New Haven, Conn., seconded, and passed that they be adopted as published.

2. Annual Report of Executive Secretary for 1955 Fiscal Year

It gives me a great deal of personal pleasure to bring you the Annual Report of the Executive Secretary, for this marks the fifth occasion on which I have done so since my affiliation with you in Portland, five years ago this month. During these years our membership has increased by almost 50 percent; our staff and services have been doubled; new and significant publications have made their appearance. Finally, our business enterprise has been expanded to the point where today we own, over and above obligations, a modest surplus of $9,000 in land and some $2,500 in office equipment. Small though these figures must sound to business men dealing in thousands of dollars daily, they nevertheless represent a considerable achievement by your elected officers and your staff.

During fiscal year 1955, ending March 31, 1955, FPRS' net membership was increased from 2,634 to 2,705. Since March 31, we have added 105 new members, bringing the total to 2,810 members as we convene here in Seattle. This represents the largest total in our history. We now have members in all 48 states, U. S. possessions, Canada, and most free nations of the world.

Financially, we started fiscal year 1955 with a balance of $29,516, of which $7,119 was surplus. During the year, our total receipts amounted to $79,163 and our total expenditures to $86,010. Accounts Receivable came to $1,065 and Accounts Payable to $276. Our balance as of April 1, 1955, amounted to $22,670. During the year, $10,735 was expended toward the purchase of the real estate and proposed Executive Office Building.

The Society's audited surplus increased $3,281 to $10,400 at the conclusion of fiscal year 1955.

Technical activities have continued to increase in the Society during the year. Noteworthy have been our 13 Subject Matter Committees and their excellent annual reports which were published in the February JOURNAL. Our publications increased both quantitatively and qualitatively during the year. A total of 22 Section meetings were held in fiscal year 1955. Sections holding most meetings during the year were Northern California, Pacific Northwest, and Carolinas–Chesapeake, 3 each. The table on page 59A lists these meetings, along with their principal features.

A highlight of the year was President Carr's appearance in 12 of our 13 Sections. The Executive Secretary or Staff attended meetings of Eastern Canada, Midwest, Great Lakes, Upper Mississippi Valley, Carolinas–Chesapeake, Northeast, and Inland Empire Sections.

The Eighth Annual Meeting of the Society, held at the Civic Auditorium, Grand Rapids, Michigan, in cooperation with the Woodworkers Industry Show, attracted a new high of 830 registrants for the 3-day meeting.

Your Executive Board, the members of which are not reimbursed for their time, effort or expense, met at two- and three-day meetings on three occasions during the year: Grand Rapids in May; Denver in September; and Madison in March. Major action included progress toward the erection of a permanent Executive Office Building of the Society in Madison.

In conclusion, I predict confidently that your future reports will continue to read as this 1955 report, showing that, on the whole, FPRS has come through another record year, as a result of strong leadership, hard work, and an enthusiastic membership. Recognizing the position of forest products as our fifth largest industry, and the great potential which it represents, our Society should become increasingly larger and more useful in forthcoming years.

3. Report of Constitution and By-Laws Committee

E. S. Harrar, Chairman, reviewed the actions leading up to the recommendation for change in the fiscal year of the Society which he was about to make to the assembled members. On March 20–21, 1955, the FPRS Executive Board voted to recommend a change in f.y. from April 1–March 31 to January 1–December 31, effective January 1, 1956. On May 3 a letter was sent to all voting members of the Society explaining the intended action at the Ninth Annual Business Meeting and the reasons for the proposed change, namely simplification of FPRS Executive Office and publications operations. It was explained that by adopting the proposed new f.y. the services which the member receives will not be altered. For example, dues will become due and payable January 1, 1956; however, the Society offers a full six months' grace period in which to pay up dues. Therefore, members will be at liberty to remit dues any time between January 1 and June 30.

E. S. Harrar moved, N. Norton seconded, that Article V., Section 2,

(Continued on page 59-A)

FOREST PRODUCTS RESEARCH SOCIETY OPERATING STATEMENT—F.Y. 1955
4/1/54–3/31/55

Cash and Savings and Loan Stock, 4/1/54			$29,516.69
Receipts:			
1954 Membership Dues	$ 28.00		
1955 Membership Dues	20,328.19		
1956 Membership Dues	20,729.72		
1957–1959 Membership Dues	45.00		
Dues Collected for Sections	4,592.00	$45,722.91	
Publications Income		22,824.44	
Other Income:			
Anchor Dividend	$ 150.00		
Service to Sections	320.08		
Miscellaneous	180.65	650.73	
Executive Office Building Contributions		1,275.00	
1954 National Meeting		8,690.65*	79,163.73 $108,680.42
Expenditures:			
Central Office Expense:			
Salaries	$26,151.49		
Supplies, Equipment, Utilities, etc.	11,354.74		
Staff Travel	1,157.62	$38,663.85	
President's Expenses		84.30	
Executive Board Expenses		395.26	
Executive Office Building, Land and Taxes		10,792.07	
Publications Expense		21,186.94	
1954 National Meeting		10,599.03	
1955 National Meeting		1,023.00	
1956 National Meeting		200.00	
Section Dues Remittances		2,654.00**	
Services to Sections		411.82	86,010.27
Cash and Savings and Loan Stock, 3/31/55			$ 22,670.15

*Note: $3,353 additional of 1954 National Meeting Income received in F. Y. 1954.
**$2,174 of 1955 F. Y. Section Dues Remittances were returned to Sections in previous year.

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Double-shielded bearing
Large grease reservoirs
Bolted-on bearing cap
Labyrinth seals

This Allis-Chalmers Bearing Design Gives More for Your Motor Dollar

The bearing cap is held tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

You can lubricate these bearings without dismantling motor. Pipe-tapped holes in the bearing housings at two points provide means for inserting new grease, flushing out old grease and of relieving pressure during re-greasing.

Look for the extra bolts on the end housing . . . the sign of greater value. Ask your Allis-Chalmers representative or Authorized Distributor to show you a cutaway section of this maintenance-cutting design. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 51B7225.

A-4610

ALLIS-CHALMERS

Minimizing Face Checking of Plywood[1]

T. E. BATEY, JR.
Technologist, Douglas Fir Plywood Association, Tacoma, Washington

A study of the factors influencing the face checking of plywood has been undertaken by the Douglas Fir Plywood Association. Of the factors tested to date, those found to affect face checking signficantly are: grain type, quality of peel, moisture content of veneer at time of pressing, and water repellent treatment of finished panels. Possibilities are shown for minimizing face checking through control of these factors.

FACE CHECKING OF PLYWOOD is a potential problem wherever appearance of the panel is a factor. It may be encountered in both interior and exterior type plywood whether finished in natural or painted. In interior work, examples of checking may be found in cabinet work, finish, and doors; in exterior applications, in such items as siding, signs, and boats.

In its aim to help manufacturers improve the product, the Douglas Fir Plywood Association began a program for studying checking of fir plywood. The over-all plan of the program consisted of finding the more important factors affecting face checking, evaluating these factors, and investigating them with a view to controlling them or modifying their actions.

Face Checking Classification

Before an intensive study of the factors influencing face checking could be undertaken, it was first necessary to develop a criterion by which the degree of checking could be evaluated. A measure was needed by which a checked face could be accurately described. In the search for such a method, certain requirements were set forth.

The first of these requirements of a measuring system was that the method should be quantitative so that the severity of checking on a panel could be described by a number. A numerical rating was necessary to allow mathematical treatment of test results, and ease in handling of measurements.

The second requirement stipulated that the measurement system be reproducible. Measured values of the same checked surface should be consistent and should be reasonably close to one another whether obtained by different operators or by repeated measurements made by the same operator. Thus the human element would be held to a minimum.

The third and perhaps most important requirement was that there be good correlation between the measurement value or checking index and the appearance of the checked surface. Due to the many combinations of frequency and size of checks found on different panels, it was proved that a checking index derived from a single factor such as frequency, width, or length of checks alone would not always agree with the visual impressions of severity of checking. For example, a surface with a great many small, fine checks would have a high numerical rating on the basis of check frequency, but might not be objectionable from an appearance standpoint. With larger checks, however, the appearance would become worse, while the frequency rating remained the same. A similar situation is encountered when checking is rated on the basis of check size alone. As the main purpose of a checking study is to improve the appearance of the panel, it is easy to see that good correlation between the checking index selected and the panel appearance is quite necessary.

The fourth requirement was that the method be sufficiently sensitive to measure relatively small differences in degree of checking and thereby be able to differentiate well between performances of test variables. A finer criterion was needed for investigative work than would be required for acceptance standards. A coarser measure might cover up small but important differences in performance which could indicate the advisability of further investigation in a given direction.

The fifth requirement was that the method be relatively simple to operate. Measurement of a checked surface should be possible in or away from the laboratory, and the method should not be so complicated as to require much time in operation.

Preliminary tests of different measurement methods showed that some combination of frequency and size of checks held the most promise. While selecting the measurement basis, however, it was necessary also to determine which checks were to be counted and measured. Many sampling systems were investigated, including such methods as random and fixed areas in which all checks or a sampling were taken, and various designs of gage lines where all or a portion of the checks crossing the lines were measured. It was felt that the sampling should give comparable results on various sized panels, should represent as fairly as possible the average condition of the panel without concentrating measurements in any section, and should be able to be reduced to a unit basis. Some form of sampling of checks crossing gage lines drawn on the face of the panel appeared best in trials. Further elimination ruled out diagonal lines as they tended to concentrate sampling in the center area when two lines were used, and changed slope in relation to the face grain with a change in size or shape of the panel, making reduction of measurements to a unit basis difficult. Thus, a "strip cruise" type of sampling of checks crossing horizontal gage lines was selected.

In view of the need for including check sizes in a checking index, a search was made for a suitable instrument with which to measure surface checks. After investigating many possibilities a shop microscope was selected (Fig. 1). This consists of a 40 power wide-field tube microscope with an internal etched scale reading directly to 0.001 inch. The tube is mounted in a support, the base of which has a built-in light source supplying a grazing light to the surface being examined. The instrument, being direct reading, is simple and fast to use, not requiring preliminary settings or readings. It is easily portable and may be used in any position on all panel sizes. The magnification is high enough to allow readings to be made swiftly without estimation down to the smallest check measured. It was decided that the smallest check plainly visible to the unaided eye under good

[1] Presented at Session IX, Veneer and Plywood, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

The Author: T. E. Batey, Jr. holds B.S. from U. of Massachusetts, M.F. from Yale U. He was formerly associated with Production Engineering Dept. of Long-Bell Lumber Co.

light should represent the lower limit in size of checks counted or measured. The size of such a check was found to be about 0.001 inch in width.

Selection of Checking Index

The next step required a test to definitely select a method of sampling and measuring face checking which would be as simple as possible and yet show sufficient sensitivity to small differences in checking. An experiment was designed so that the results could be analyzed statistically by the analysis of variance technique, thus providing a measure for the sensitivity.[2] The test involved three factors each at two levels and with each level replicated once. The factors used—type of exposure, cycles of exposure, and water repellent treatment—were chosen to produce different degrees of checking among groups.

The test plan called for analyzing the effects of these three factors on the face checking of carefully matched plywood specimens as measured by several different methods for rating checking. Thus, upon completion of exposures, the face checking on all panels was measured by all of the methods of sampling and measurement which were judged to hold promise. An analysis of variance was then computed for each measurement method, and that method which showed the greatest sensitivity to differences between variable levels was chosen as most desirable.

The rating system selected used two gage lines drawn across the face of the panel at right angles to the direction of face grain, and located approximately at the third points of the panel edge. All checks visible to the unaided eye crossing the gage lines were counted. The total number of checks crossing gage lines was divided by the total length of gage lines, reducing the check frequency value to a basis of checks per lineal inch of gage line. While counting, each fifth check was marked in pencil, and on completion of the frequency tabulation these marked checks were measured for width at the point of crossing the gage lines (Fig. 1).

Width measurements were multiplied by 1000 for ease in handling by substituting whole numbers for thousandths when using the direct reading shop microscope. A value for the average width of check was obtained by dividing the accumulated widths by the number of checks measured. Although measurement of every check included in the frequency count would result in a more thorough sampling,

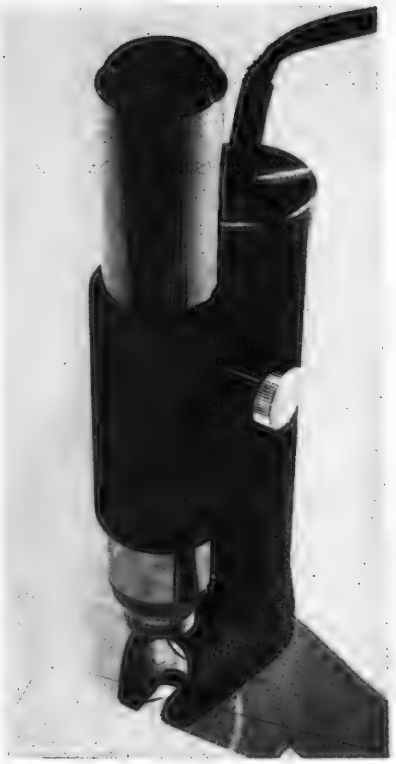

Fig. 1.—Shop microscope with direct reading internal scale and built-in light source, set up to measure width of marked check at point of crossing gage line.

it was found that width measurements made on each fifth check gave an average check width of sufficient accuracy and at the same time required less work in measuring. When total frequencies fall below 15 or 20, however, more intense width sampling is desirable.

The checking index or numerical value for degree of checking was obtained by multiplying the figure for checks per inch of gage line by the average width of checks (x 1000). This index, in effect, gives a value equal to ten times the percentage of gage line taken up by checks. Examples of panels with different degrees of face checking are shown in Fig. 2.

The last step in testing the suitability of this checking index was to insure that good correlation existed between the index and panel appearance. To accomplish this, several groups of panels of the same size and finish were arranged to include various degrees of checking severity. The checking index value for each panel had been recorded separately with the code number of the panel.

The panels in each of these groups were then graded by different people in accordance with their impressions of the severity of checking, and these rankings compared with the rankings determined by measurement. Panel gradings were made by persons with varying degrees of familiarity with plywood. In general, the correlation between checking measurements and ocular classifications was quite good and satisfied the requirements for acceptance of the checking index tested.

Since the index selected satisfied the prescribed requirements by being a numerical measure with good reproducibility, sufficiently sensitive to record relatively slight differences in panel performance, was simple to use, and also agreed well with panel appearance, it was considered a satisfactory criterion for the measurement of face checking.

Sample Preparation

In the course of developing a program for the study of face checking, attention was given to the preparation of test samples. Early tests had shown that checking after exposure was more concentrated along the top and bottom edges of a panel with unprotected edges, due to the higher rate of moisture transfer through the end grain surfaces of the faces. In order to minimize this condition, panel edges were sealed with a double application of a plastic resin sealer. The material may be applied by dip, brush or roller, and its use helps insure against confounding of panel checking performance due to the inclusion of the added factor of different rates of gain and loss of moisture through the end grain surfaces. A good edge seal permits the use of smaller test samples by simulating the interior of a larger panel.

Although the checking index may be used with any size or shape of specimen, a 10-inch square panel was adopted as the standard for laboratory studies with accelerated exposures. This size was shown to supply reliable results of panel performance when edge sealed, and permitted closer matching and control of panel characteristics. Thus, samples could be cut from a large panel in such a manner as to match along the face grain, taking advantage of the closer similarity in physical characteristics of the veneer along the grain and reducing the chances of including differences such as angle of peel and varying density often encountered across the grain. Further, a 10-inch specimen is convenient to handle and allows a greater number of samples to be used than would be practical with a larger size.

Because unfinished or raw plywood presents such a difficult and varied surface for examining checks, prior to exposure samples were given a light spray coat of interior white foundation undercoat paint thinned with mineral spirits. This white coat did not offer any significant protection or alter the performance of the faces, but did make

[2] Acknowledgment is expressed for assistance and suggestions in the statistical phases of this work supplied by Dr. Ben S. Bryant, Assistant Professor of Forest Products, College of Forestry, U. of Washington.

the checks much more visible and easier to count and measure. The coating also gave a more uniform surface on which to work. The paint is thin enough to rupture easily wherever checks develop in the face veneer, and there is no bridging of paint over checks which would hamper their measurement.

Standard Exposure

The next requirement necessary to a checking study was a standard test exposure to which all test specimens would be subjected. The exposure should be severe enough to produce considerable checking in the prepared samples, but not so severe as to produce such a high degree of checking that any differences due to variables in panel make-up would be obliterated. At the same time, exposure conditions should be relatively easy to obtain and maintain, with a minimum of reliance on apparatus.

The prime object of the exposure was to produce checking in the test specimens, but on an accelerated basis compared with that obtainable in natural weathering. Also, a uniform exposure which could be duplicated was desirable to place different sample batches on a comparable basis. An artificial exposure, accelerated sufficiently to be practical for laboratory studies, may differ considerably from expected natural conditions. Nevertheless it will give a useful measure of the differences in the effects on checking of the factors tested. Factors showing promise under the more severe laboratory exposure will be field tested under actual weathering conditions.

As checking usually develops after changes in moisture content of the panel face, the logical laboratory exposure would consist of cyclic wetting and drying (6).[3] Preliminary experiments, including the one previously described which was used to select the checking index, supplied considerable information useful in determining the best exposure. The schedule selected consists of an 8-hour soak in water at room temperature, followed by a drying period to equilibrium under 50 per cent relative humidity at 80° F., resulting in a moisture content in the panel of about 8 per cent. This treatment is repeated as often as desired or until adequate checking develops. Checking may be measured at the end of any dry cycle.

The advantages of a water soak over exposure to high humidity outweighed the disadvantages, as the soak was much quicker, more uniform and consistent, simpler, and required less elaborate equipment. The drying conditions were easy to maintain in a conditioning chamber, and being near normal room conditions, facilitated the handling of specimens at time of inspection. Although the cyclic exposure described is used for both exterior and interior type plywood, additional companion specimens are subjected to high humidity conditions for the upper moisture content phase of panel exposure, where comparison of the effects of a soak and a high humidity exposure is desired.

[3] Numbers in parentheses refer to literature cited.

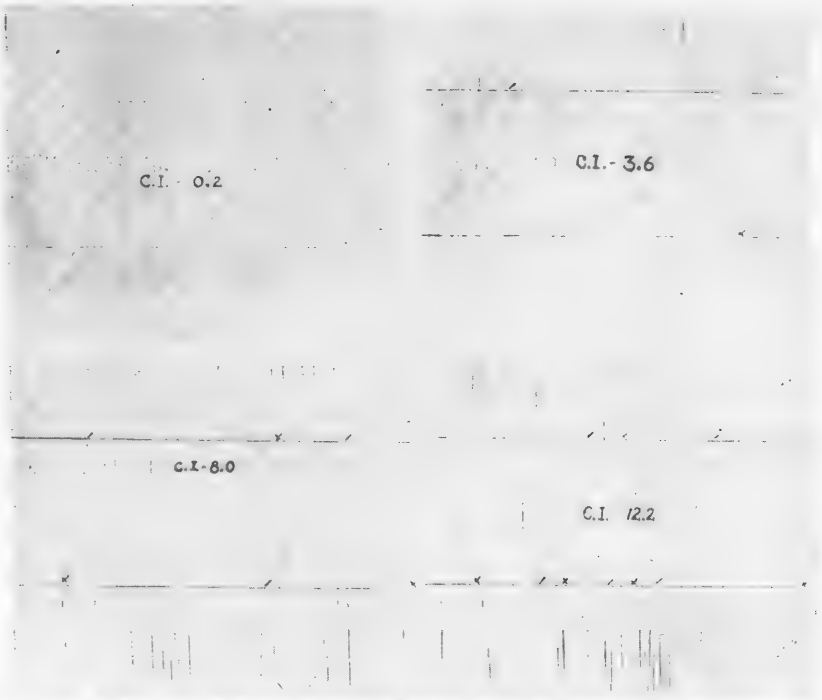

Fig. 2.—Examples of various degrees of face checking. All visible checks crossing gage lines are counted, and each fifth check marked for width measurement. The checking index values shown on each panel are obtained by multiplying the number of checks for lineal inch of gage line by the average width of measured checks times 1000.

Investigations of Factors Affecting Checking

Having the tools necessary for the study of face checking, the next phase of the program dealt with investigations of some of the more important factors which affect checking. Preliminary tests were conducted and the results of these, in addition to those from earlier tests, were used to develop designs for major experiments. The designs of all experiments were in accordance with recognized statistical procedure, that most employed being the analysis of variance technique (2, 4). In this way, it was possible to study several variables at one time, with each variable operating at more than one level. In addition to evaluating the relative effects of the individual main factors, the interactions of these factors are measured statistically by this technique.

Of the factors investigated to date, those shown to have considerable effect on face checking of both laboratory and mill manufactured fir plywood were used in one experiment designed to test them together under controlled mill conditions.

The first factor was grain type, i.e. relative coarseness of grain. It was considered desirable to test all other variables over more than one grain type in order to learn of any possible differences in performance of variables between grain types. Also, more meaningful conclusions could be drawn concerning the effect of a variable where it had performed similarly over quite different grain types. The term "grain type" as used here indicates the number of annual growth rings per inch (9, 13).

It had been noted that face checking most often concentrated in the wide areas of summerwood that are present in veneer peeled from the coarser grained logs, while similar patterns were not present in fine grained veneer. Grain type, rather than specific gravity or per cent of summerwood, was used as the first variable to be encountered in the production process, although complete data from all logs were obtained.

Two levels were included in this factor, each represented by one Douglas-fir log. The fine grain log averaged 16 rings per inch in the region peeled for test, and had a specific gravity of 0.41 (oven-dry basis), with about 25 per cent summerwood. The coarse grain log averaged 7 rings per inch in

the peeled area, and had a specific gravity of 0.45, with about 40 per cent summerwood.

The next factor in the design was quality of peel, as evidenced by looseness or tightness of cut (11, 8). The effect on face checking of various degrees of lathe checking in the veneer had appeared increasingly important in earlier tests. It was desirable, therefore, to establish whether or not a positive correlation existed between quality of cut and subsequent face checking.

In order to get positive differences in peel quality, adjustments were made at the lathe to produce the cut desired (5). The two logs selected for the grain type factor were cut to produce three 8-foot blocks (plus trim allowance) each, the blocks in one log being immediately adjacent to one another.

The first block, selected at random from the six, was peeled to a predetermined depth under the sapwood, at which point the lathe operator adjusted his lathe to produce as tight a peel as he could. A sufficient quantity of veneer was removed from the green chain in a separate load and marked. Color code markings were also applied to the edge of the veneer by a man stationed in front of the clipper to insure correct separation of test stock.

Next, a block from the other grain type was selected at random, peeled to a predetermined depth under the sapwood, and adjustments again made to the lathe to produce the tightest possible peel. As the second block differed considerably in grain characteristics from the first, the lathe settings required to produce a tight peel were not the same. All lathe adjustments which were made to produce the different peel qualities concerned the position of the roller pressure bar in relation to the knife edge. Thus, both the vertical opening, or vertical distance between the knife edge and pressure bar, and the horizontal opening were increased to produce a looser cut veneer. The knife angle was changed only with changes in block diameter in accordance with standard operating procedure. The experience of the lathe operator was relied upon in making all lathe adjustments to produce the desired quality of peel.

The tight veneer from this second block was also code marked on the chain and sheets pulled into another separate package. A similar procedure was followed with the next two blocks, i.e., one of each grain type, except that these were peeled to produce a medium peel, a quality between a tight and a loose peel. The remaining two blocks were peeled to produce a loose peel.

Fig. 3.—Sawing through stained area of veneer preparatory to sanding.

The quantity of veneer required in the test precluded the use of only one block per grain type for all three qualities of cut, especially since only full size sheets of veneer were used. It was felt, however, that an even better matching of grain characteristics was afforded among the peel types with matching through blocks along the log, taking the test material from a given point on the radius of the log, rather than peeling too deeply into one block for all material of a grain type.

In the course of studying the effect of quality of peel on face checking of plywood, it became necessary to actually measure the severity or degree of lathe checking, instead of using the descriptive terms tight, medium, and loose. The important factor of lathe checking as it affects face checking seems to be the proportionate depth of the lathe checks through the thickness of the veneer, or the proportion of the thickness of the veneer in solid wood left between the surface and the ends of the checks. The measure of lathe checking which has been found satisfactory is the estimated proportion of the thickness of the veneer through which the checks extend. No consideration is given to the number of checks in this case.

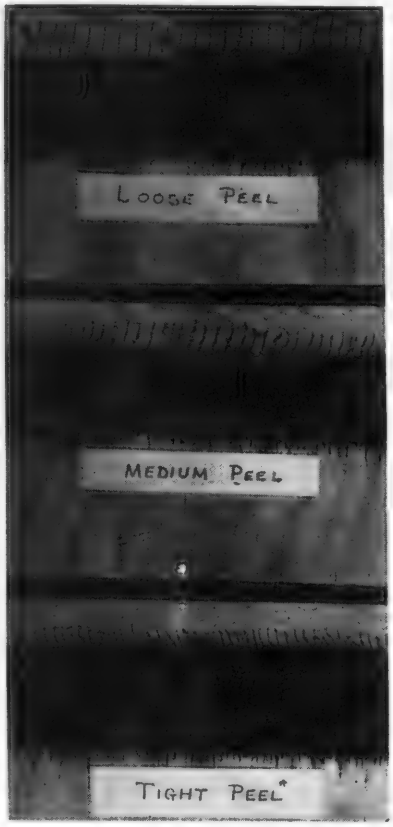

Fig. 4.—Stained, cut and bevel sanded veneer samples showing three qualities of peel as evidenced by the depth of lathe checks. The quality of peel is measured by the proportion of the thickness of the veneer through which the lathe checks extend, and is estimated easily on the beveled sections.

The simplest way to measure lathe checking is to mark the veneer being examined into even increments of one inch across the grain, estimate the depth of checks in each one-inch section, and average the results for the piece. Due to the variability encountered in check depths, values are not read closer than to 10 or possibly 5, in a scale to 100. Thus a sample with check depths averaging one-half the thickness of the veneer would have a rating of 50, while one with checks three-quarters of the way through the veneer would have a rating of 75.

It is most difficult, and sometimes impossible, to see the full extent of the depth of lathe checks on plain veneer. To make these checks plainly visible a simple technique was developed which may be used in the laboratory or in the mill. This means of rendering lathe checks easily visible by staining and sanding has advantages over other described methods (10) by being simple and fast to perform.

A powdered black alcohol-soluble dye or stain, obtainable in any paint store, is mixed with alcohol in sufficient concentration to produce a strong black color when applied to wood. The solution is brushed across the grain of the veneer to form a stripe on the loose side of the piece, or may be applied to both sides where identification of the loose and tight sides is difficult. It is advisable to keep the stained area away from the end of the veneer to prevent penetration of stain into the end grain which would color the wood as well as the checks.

Within a matter of minutes, depending upon the amount of stain used, the section is dry enough to cut and sand. The specimen is then sawn across the grain through the stained area (Fig. 3), and the cut piece is sanded on a long, uniformly-sloped bevel on the loose side to better display the stained checks. Examples of specimens prepared in this manner from veneer with three different degrees of lathe checking are illustrated in Fig. 4.

When the bevel is completely sanded from face to back of the ve-

neer, the average depth of the lathe checks and the proportion of the thickness of the veneer left in solid wood beyond the checks may be estimated from the distance the checks extend across the bevel. The whole operation takes but a few minutes to perform, and has been used successfully by some mills as a spot check on their quality of cut, and to better show their personnel the kind of peel being produced. Equally good results are obtained with wet veneer as it comes from the lathe or with dried stock.

Although this technique works best with veneer, it may be used with plywood with some changes. In normal plywood the tight side of the face veneer is exposed, and surface application of the stain cannot be used. The procedure then consists of applying the stain to an end section of plywood across the grain of the face, and bevel sanding without sawing. Care must be taken that the stain is dry before sanding or the section will smudge.

Returning to the mill study under discussion, random samples of veneer were taken after drying and prior to glue-up. Measurements of the degree of lathe checking were made on a minimum of at least five samples in each category of grain type, quality of peel as manufactured, and moisture content group to which the veneer was dried. The average values for these groups are shown in Table 1. It will be noted that a greater spread in degree of lathe checking was obtained in the fine grain stock than in the coarse, although this does not necessarily mean that more severe lathe checking cannot be or is not produced in coarse grain veneer.

The third factor to be tested in the experiment was the moisture content of veneer at the spreader, or at time of layup. This factor had proved to be significant in its effect on face checking in former tests in which as many as four levels of moisture content were studied. At this time, three levels of moisture content were considered sufficient, and target values of 2, 5, and 8 per cent were selected.

The six packages of veneer, representing three qualities of peel for each of two grain types, were rearranged into three groups for drying, so that each peel class and grain type would be further divided into three moisture content groups. All sheets were carefully code marked so as to be easily identified.

Although tests were conducted with the stock to be dried to determine the dryer schedules necessary to attain the desired moisture content values, control was lost in the actual runs through the dryer. The actual moisture contents obtained in the three groups as determined by oven drying tests, consequently, were 1.9, 2.2, and 4.4 per cent. These averages, however, were quite uniform within their groups and were arrived at by testing a minimum of 30 specimens per moisture content group. Although the desired spread in moisture content classes was not attained, and even though the lower two groups were essentially the same, the values worked to advantage as will be shown later.

Table 1.—QUALITY OF PEEL OF TEST VENEER

Grain Type	Quality of Peel	Moisture Content Group 1.9%	2.2%	4.4%	Avg.
Fine Grain	Loose	67†	71	73	70
	Medium	47	40	47	45
	Tight	23	22	25	23
Coarse Grain	Loose	58	56	55	56
	Medium	51	49	51	50
	Tight	48	34	38	40

†Values represent the average length of lathe checks expressed as a per cent of the thickness of the veneer through which the checks extend.

A laboratory pilot run had been made to determine whether the moisture content of the core stock had any significant influence on the face checking of 3-ply panels. As the results indicated that core moisture content had no measureable effect on checking, all core material for the test was dried to a single moisture content, about 5 per cent. Also, all core stock used in the test panels was cut from one block. The same thickness veneer, 1/10 inch, was used for core stock as was peeled for faces.

After drying the veneer, the sheets were sorted for lay-up so as to make two full size 4 x 8 ft., 3-ply panels for each category of grain type, quality of peel and moisture content group, or 36 panels. As only the defect-free portions of the panels would be used in testing, the best sheets in each veneer group were used for both faces and backs of panels. Two-ft. wide core stock was used to keep core joints and possible voids to a minimum. All panels were then glued with a cold press protein adhesive, using the recommended spread and pressing schedule. The following day the panels were trimmed and sanded to ¼-inch thickness as carefully as possible to insure uniformity between panels and equality between faces and backs. Identification markings were replaced after sanding.

The last variable brought into the experiment was treatment of the finished plywood with a water repellent solution. The effects on face checking of water repellents had been studied earlier, with treatments applied in the laboratory by dip and by brush. The favorable effect on checking shown by such treatment prompted the desire for a test of its value when applied immediately after manufacture, before the plywood had been subjected to any kind of exposure in shipping or storage, and applied under production conditions by a mill flood treatment.

One half of each test panel (4 x 4 ft.) was put through a mill oiling machine which sprayed a standard commercial water repellent solution on both sides. With this type of matching along the grain of the faces between treated and untreated sections, a good measure of the effect of treatment on face checking was possible. After wet stacking panels overnight, all groups were carefully wrapped in separate packages with waterproof paper and shipped to the laboratory for testing.

On receipt at the laboratory the panels were conditioned to 8 per cent equilibrium moisture content and then were cut to provide four 10-inch square specimens for each category of grain type, peel quality, veneer moisture content group, and treatment condition, or a total of 144 specimens. These were selected to have defect-free faces and backs, thus providing two measurement faces per piece, or a total of 288 faces. All specimens were code numbered for identification, edge sealed and white coated, and subjected to the standard soak-dry exposure. Checking was recorded at the dry end of the third and sixth cycles. The discussion deals with the results after six exposure cycles.

Analysis of Test Results

The checking index values were recorded for all 288 panel faces. Although each category or cell of the design was represented by eight panel faces, each face was treated as an individual in the analysis. Table 2 shows the average values for the eight faces in each cell.

In the analysis of variance, the total variance (a measure of variation) of a process is analyzed into its component factors, after which the relative importance of these factors can be determined (2). In the analysis under discussion, therefore, each individual factor is separated for study by averaging out all other factors, and in a similar manner the interactions of factors are separated.

Thus, the Master Table given in Table 3 lists the four main factors of grain, peel, moisture, and treatment, the first order interactions of all combinations of pairs of these main factors or the joint effects of one main

Table 2.—EFFECT ON FACE CHECKING OF GRAIN TYPE, QUALITY OF PEEL, VENEER MOISTURE CONTENT AND WATER REPELLENT TREATMENT
Data Table

Treatment	Quality of Peel	Fine Grain: Moisture Content Group 1.9%	2.2%	4.4%	Avg.	Coarse Grain: Moisture Content Group 1.9%	2.2%	4.4%	Avg.	Avg. Coarse and Fine Grain	Avg. Treated and Untreated
Treated	Tight	0.1†	0.4	0.1	0.19	3.2	2.6	5.2	3.67	1.93	3.03
	Medium	1.9	0.5	1.0	1.10	4.0	3.5	5.7	4.39	2.75	4.96
	Loose	3.3	3.2	8.5	5.00	4.6	5.7	8.4	6.26	5.63	7.04
Avg.		1.76	1.35	3.18	2.10	3.96	3.95	6.42	4.77	3.44	
Untreated	Tight	1.4	1.5	2.5	1.78	7.6	5.8	6.1	6.48	4.12	
	Medium	3.7	2.3	2.7	2.90	9.4	11.4	13.6	11.44	7.17	
	Loose	6.7	7.5	7.9	7.34	8.1	9.5	11.1	9.54	8.44	
Avg.		3.92	3.74	4.36	4.01	8.35	8.87	10.23	9.15	6.58	
Avg. Treated and Untreated		2.84	2.55	3.77	3.05	6.15	6.41	8.33	6.96		
Avg. Fine and Coarse Grain		4.50	4.48	6.05							

†Each individual value is the average of the checking indices of eight faces.

Table 3.—EFFECT ON FACE CHECKING OF GRAIN TYPE, QUALITY OF PEEL, MOISTURE CONTENT OF VENEER, AND WATER REPELLENT TREATMENT
Master Table—Analysis of Variance

Source of Variation	Degrees of Freedom	Net Sum Squares	Mean Squares	Variance Ratio (F)	Significance†
Total	287	5,049.27			
Grain Type	1	1,100.19	1,100.19	170.0	***
Peel Quality	2	771.16	385.58	59.6	***
Moisture Content Veneer	2	156.06	78.03	12.1	***
Treatment with Water Repellent	1	710.33	710.33	110.8	***
Grain x Peel	2	211.00	105.50	16.3	***
Grain x Moisture	2	18.66	9.33	1.4	NS
Grain x Treatment	1	109.65	109.65	16.9	***
Peel x Moisture	4	73.02	18.25	2.8	*
Peel x Treatment	2	63.88	31.94	4.9	**
Moisture x Treatment	2	16.81	8.40	1.3	NS
Grain x Peel x Moisture	4	54.77	13.69	2.1	NS
Grain x Peel x Treatment	2	69.88	34.94	5.4	**
Grain x Moisture x Treatment	2	0.52	0.26		NS
Peel x Moisture x Treatment	4	36.29	9.07	1.4	NS
Experimental Error	256	1,657.05	6.47		

†Significance is noted as follows: NS indicates not significant statistically; significant (*) refers to a 5 per cent probability or one chance in twenty that a difference as great as that found would be due to chance sampling; highly significant (**) refers to a 1 per cent probability; and very highly significant (***) refers to a 0.1 per cent probability.

factor acting with another, and the second order interactions of three main factors acting together. The variance ratio is calculated for each source of variation and compared with values found in the statistical Table of F in accordance with statistical procedure (1, 2, 3, 7, 12).

The relative effects of the factors studied are shown in the Master Table (Table 3), together with the statistical significance of their effects.[4] The effects on face checking of each main factor averaged over the effects of all other factors are shown graphically in Fig. 5, and the effects of the various combinations of grain type, peel quality and treatment factors are shown in Fig. 6.

Considering first the effect of grain type on face checking, the Master Table shows this factor to be very highly significant. It is the most significant main factor of the four, with a variance ratio nearly 16 times larger than is required for significance at the 0.1 per cent level. As the effect of this factor is significantly greater than each first and second order interaction which include grain type, it may be concluded that the effect of grain type on face checking is significant irrespective of moisture content of veneer at assembly, quality of peel, or water repellent treatment, or their interactions (7).

Thus, it is possible to generalize within the limits of this experiment that a coarse grain, higher specific gravity veneer will check significantly more than will a fine grain, lower specific gravity material, regardless of the quality of peel, original moisture content of veneer, or the application of surface treatment, providing the levels of these factors are the same for both grain types.

The data table shows that the average checking index of all coarse grain panels was 6.96, while that of the fine grain panels was 3.05, or that there was more than twice the checking in coarse than in fine grain material. Similar effects of grain type on checking have been noted on several tests made previously.

The effect of quality of peel on face checking is also seen to be very highly significant, with a variance ratio about eight times greater than that required for significance at the 0.1 per cent level. It may be said that the effect of peel is significant regardless of original veneer moisture content or treatment, but the test results require that a general statement of effects of peel be qualified because of a discrepancy brought about by the grain x peel x treatment interaction. This interaction is illustrated in Fig. 6 and tabulated below in terms of the checking index.

The discrepancy appears in the coarse grain, medium peel, untreated average, the value being higher than would be expected from the balance of the data. A possible explanation for this value being out of line is that some very loose cut veneer was produced and used from the medium peel of the coarse grain block.

Reference to Table 1 shows the coarse grain medium and loose peel groups to be closer in degree of lathe checking than any other groups, and it is reasonable to believe that some sheets, or portions of sheets, of medium peel veneer were more typical of a loose peel quality. The fact that the discrepancy showed up only in the untreated sections and not in the treated is difficult to interpret except as a phenomenon of sampling. Otherwise, the strong effect of quality of peel is well shown in Figs. 5 and 6.

The greater spreads in the effects of peel qualities depicted in the fine grain group over those in the coarse grain class are in line with the greater differences in severity of lathe checking of fine grain over coarse grain veneer listed in Table 1. The average

EFFECT ON FACE CHECKING OF GRAIN X PEEL X TREATMENT INTERACTION

	Tight Pee		Medium Peel		Loose Peel	
	Coarse	Fine	Coarse	Fine	Coarse	Fine
Untreated	6.48	1.78	11.45	2.91	9.45	7.34
Treated	3.67	0.19	4.40	1.10	6.26	5.00

[4] In this work the term "significant" is used in the sense of statistically significant: significant (*) refers to a 5 per cent probability that a difference as great as that found would be due to chance sampling; highly significant (**) refers to a 1 per cent probability; and very highly significant (***) refers to a 0.1 per cent probability.

checking index for all tight peel panels was 3.03, for medium peel 4.96, and for loose peel 7.04 (Fig. 5).

The effect on face checking of the next major factor, moisture content at time of gluing, is also very highly significant, its variance ratio being nearly twice that required for significance at the 0.1 per cent level. As the effect of this factor is significantly greater than all interactions which include the factor of moisture, it may be stated that within the limits of this test a higher moisture content in the veneer at lay-up results in more severe face checking, regardless of the grain type, quality of peel or treatment of the panel.

It was pointed out earlier that the target moisture contents of the test veneer were not attained in the drying operation, and that the two lower moisture content groups of 1.9 and 2.1 per cent were, for practical purposes, the same. In such case, the checking performance of panels into which veneer of these two moisture groups were incorporated should be the same. With average checking of 4.50, 4.48 and 6.05 for moisture content groups of 1.9, 2.1 and 4.4 per cent respectively, the data and Fig. 5 show this fact to be true, while the difference in the effect of the higher moisture content group over that of the lower groups is very highly significant.

These results serve as a check on a previous mill test in which four moisture content groups were used, 1.4, 2.5, 4.9 and 7.9 per cent. The difference in effect on face checking between the lower two groups was non-significant, but the difference between the 2.5 and 4.9 per cent groups was very highly significant and that between the 4.9 and 7.9 per cent groups

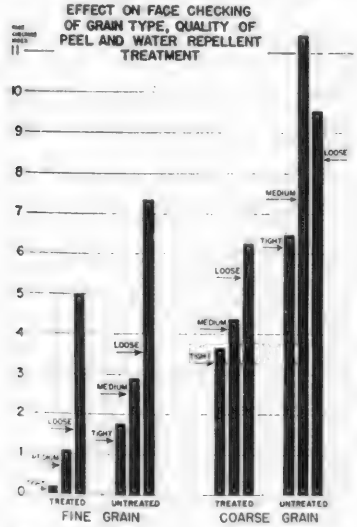

Fig. 6.—Interaction chart of three main factors showing the effects on face checking of the various combinations of these factors operating at different levels.

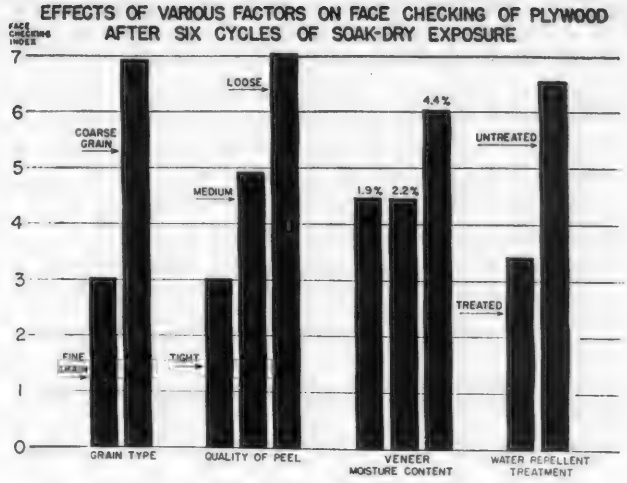

Fig. 5.—Effects on face checking of four individual factors, each averaged over the effects of the other three factors.

was highly significant. The average checking indices for these panels were 1.86, 2.20, 4.64 and 6.03 respectively, the figures being the averages of 32 faces each, with standard exposure of only five cycles.

The following table of the interaction of quality of peel and veneer moisture content in the test under analysis shows the interesting condition that the tighter the peel, the less influence veneer moisture content has on checking.[5]

Quality of Peel	Veneer Moisture Content 1.9%		2.1%		4.4%
Tight	3.06	(NS)	2.54	(NS)	3.49
Medium	4.75	(NS)	4.41	(*)	5.71
Loose	5.69	(NS)	6.47	(***)	8.96

Thus, the difference in effect on checking between the low and high moisture groups in the tight peel is non-significant (NS), in the medium peel it is significant (*), and in the loose peel it is very highly significant (***).

The effect on face checking of the last main factor, water repellent treatment, is also very highly significant, with a variance ratio about ten times greater than that necessary for significance at the 0.1 per cent level. The effect of treatment is significantly greater than the effects of all interactions which involve the treatment factor except the treatment x grain type interaction. On this basis, then, it may be said that the effect of a water repellent treatment significantly reduces the face checking of plywood, within the limits of this test, regardless of the quality of peel or original moisture content of the veneer.

The discrepancy with respect to the treatment x grain type interaction is interpreted as caused by the same grain type x peel x treatment interaction discussed earlier, in which the coarse grain, medium peel, untreated group average appeared out of line with the balance of the results. The average checking index for all untreated specimens was 6.58, while the index for treated panels was 3.44 (Fig. 5). It appears then that the water repellent treatment of the panels applied immediately after manufacture served to reduce face checking to one-half that which occurred in the untreated specimens. This effect of such a treatment agrees with results obtained in several earlier experiments.

[5] The test for significance between averages used here is an adaptation of the conventional "t" test.

Conclusions

The method which has been developed for sampling and measuring surface checks on plywood provides a satisfactory and workable basis by which to classify the severity of face checking. This check rating system has been shown to satisfy the requirements stipulated as necessary to intensive investigations of the possible factors affecting face checking.

The strong difference in effects on checking displayed by different grain types indicates the desirability of selecting finer grain faces where checking must be held to a minimum. The quality of peel influences face checking to such a great extent that every effort should be made to manufacture face stock with as tight a peel as possible. The improvement in checking performance afforded by the use of veneer of lower moisture content in cold press plywood shows the importance of adequate veneer drying, particularly where other factors conducive to checking, as coarse grain and loose peel quality, may be present. The application of a water repellent treatment immediately after manufacture of the plywood has been shown to reduce face checking markedly.

The low level of face checking obtained in the experiment described,

when the most favorable levels of each variable were combined, as opposed to the severe checking which resulted when the least favorable levels of variables were used, indicates the possibilities for minimizing plywood face checking by the intelligent control of the factors involved. The results thus shown encourage further study along such lines as improvement in the quality of peel, as well as investigations of other manufacturing variables which might affect the face checking of plywood.

Literature Cited

1. Bliss, C. I. and Calhoun, D. W. 1954. An outline of biometry. Yale Co-Operative Corp., New Haven, Conn.
2. Brownlee, K. A. 1953. Industrial experimentation. Chemical Publishing Co., Inc., New York.
3. Bryant, B. S. 1952. Methods for testing the significance of differences between sets of experimental data. Unpublished monograph.
4. Fisher, R. A. 1951. The design of experiments. Hafner Publishing Co., New York.
5. Fleischer, H. O. 1949. Experiments in rotary veneer cutting. FPRS Proc. III: 137.
6. Holcombe, R. A. 1952. Surface checking in furniture panels. Jour. FPRS II (5):122.
7. Immer, F. R. 1950. Applied statistics. Burgess Publishing Co., Minneapolis, Minn.
8. Jayne, B. A. 1953. Finish checking of hardwood veneered panels as related to face veneer quality. Jour. FPRS III (3):7.
9. Koehler, A. 1924. The properties and uses of wood. McGraw-Hill Book Co., Inc., New York.
10. Limbach, J. P. 1946. A method of measuring checks in veneer. Jour. of Forestry 44(7):509–511.
11. Perry, T. D. 1948. Modern plywood. Pitman Publishing Corp., New York.
12. Snedecor, G. W. 1946. Statistical methods. The Iowa State College Press, Ames.
13. Wangaard, F. F. 1950. The mechanical properties of wood. John Wiley & Sons, Inc., New York.

Discussion

Russell K. Stensrud (Reichhold Chemicals, Inc.): What kind of glue was used and what press temperatures?

Mr. Batey: In the test described, an interior type cold press protein adhesive was used.

Mr. Stensrud: Has an experiment been considered to determine the effect of high temperature pressing in the order of 270–300° F.?

Mr. Batey: To date, only laboratory experiments have been conducted on hot vs. cold press plywood, but a mill experiment including this factor has been designed and will be completed soon.

Mr. Stensrud: What would be the effect of using tight-peeled veneers loose side out on a face or back? Wouldn't the lathe checks tend to relieve the surface stresses and lessen further face checking, much like tenderized veneer?

Mr. Batey: Unless that portion of the face containing lathe checks was completely removed in sanding, the existing lathe checks would enlarge with a drying exposure to produce face checking. If the lathe checks were removed in sanding, however, the remaining solid wood in the face should be better able to resist shrinkage stresses than would a face containing zones of weakness in the form of lathe checks, and face checking would be minimized.

J. S. Bethel (N. C. State College): Did you evaluate the effect on face checking of position of veneer along the radius of the log?

Mr. Batey: Position of veneer on the radius of the log was not a factor in this study. All test veneer was taken under the sapwood from about the same point on the radius of each block, so as to match well along the grain between blocks from a given log.

C. E. Close (Hardwood Plywood Institute): The practice on the West Coast is to cut cold. What would be the influence of soaking logs in hot water or steam, or both, before cutting?

Mr. Batey: It is generally considered that veneer from heated logs will lathe check less than that from cold blocks. We have no data at present on the relative effects of hot and cold peeling, but have a mill study covering this factor under way. Some mills do heat their blocks now, and others contemplate heating.

O. H. Schrader, Jr. (U. S. Plywood Corp.): It is recognized that preheating would reduce face checking, but it is too costly with present markets.

S B. Preston (U. of Michigan): Were different types of water-repellent dips tried or was one selected?

Mr. Batey: One commercial water repellent was used in this work.

E. G. Hallonquist (MacMillan & Bloedel, Ltd.): Does the use of a water repellent as in this work affect the paintability of the plywood?

Mr. Batey: Not adversely.

C. S. Walters (U. of Illinois): Usually, growth rate and per cent of summerwood have some effect on solution absorption. Did you measure the rate of absorption for the various types of veneer?

Mr. Batey: No, rate of absorption was not studied.

W. Williams (Borden Co.): What were the important interactions that were significant in your analysis of variance?

Mr. Batey: The important interaction between peel quality and veneer moisture content was significant. This interaction showed that the tighter the peel, the less influence moisture content of veneer had on face checking. This means that with a tight peel there was no significant difference in face checking between veneer moisture content groups in the range tested. With increased looseness of peel, however, the difference in checking due to veneer moisture content became greater and more significant. The significant grain x peel x treatment interaction, as well as its two-way interaction components, involved the apparently out-of-line value for coarse grain, medium peel, untreated panels which was discussed earlier.

E. W. Wellwood (Canadian Forest Prod. Ltd.): Did you record the amount of water repellent used to surface treat samples? If not, have you any data to indicate what minimum amount should be used to produce significant improvements in reducing the amount of face checking?

Mr. Batey: Although we did not measure the amount of solution used, it was the minimum quantity that could be applied by standard mill flood treatment.

G. C. Perkins (Elliott Bay Lbr. Co.): For water repellents applied by an oiling machine in the average fir mill, the coverage has been found to be approximately 2½ to 3 gallons per 1000 square feet on sanded fir plywood and 4½ gallons/1000 on rough plywood. Available test data indicates that this coverage is adequate for most purposes.

J. M. Yavorsky (State U. of N. Y. College of Forestry): In your analysis of the effects of moisture content, the values of 1.9 and 2.2 per cent moisture content represent average values, I assume. I am curious as to how you could separate the material into two categories with averages as close as these. What was the scatter within these groups and did these average values differ statistically, when tested with the "t-test," for example?

Mr. Batey: These moisture content values were averages of a large number of samples, and the scatter within each group was small. Although there was no significant difference between the two groups, each group was handled separately under different drier schedules. Even though the moisture content averages were sufficiently close to be called the same, therefore, the two groups were required to be analyzed as separate groups in the analysis of variance. As was discussed earlier,

the fact that the two moisture content groups having about the same value produced identical degrees of checking served as a good check.

E. Reichman (Simpson Logging Co.): Did you try an accelerated drying schedule to induce checking? Would drying at 150° F. result in a different checking index? Is the different index value due to size of checks rather than the frequency?

Mr. Batey: A drying schedule more accelerated than the one we have adopted as standard for checking studies would produce more severe checking. With higher temperatures and/or lower relative humidities, the drying rate would increase, causing a greater degree of face checking. One of the functions of a water repellent in reducing checking appears to be its slowing down of the rate of moisture loss, as well as its reduction of moisture gain.

The different index values among all panels in the test are due to various combinations of size and frequency of checks. Within one panel, however, early exposures produce a check frequency that increases little on subsequent exposures. The checking index goes up with repeated cycles of exposure due mainly to the increase in width of the checks.

A New Method for Evaluating Interior Plywood[1]

H. W. HAIGH

American-Marietta Co., Seattle, Wash.

Discusses a test method which has proven useful in evaluating interior plywood bonds. Agricultural experimenters have developed statistical methods to study data which may be scattered due to uncontrolled variables. These methods are gaining rapid acceptance in adhesive research due to the heterogeneous nature of wood and the difficulty of obtaining clear and concise data by conventional methods. This method, developed to fit into statistically designed experiments, is shown to be sensitive to gluing variables.

THE DOUGLAS-FIR PLYWOOD INDUSTRY recognized the need for control of product quality and established an extensive system of quality checking under the Douglas Fir Plywood Association (1).[2] This organization supervises the quality of plywood produced by all of its member mills, being guided by the general standards for Douglas-fir plywood as recorded in the Commercial Standards (2). The latest revision of the series, CS 45–55, effective Feb. 1, 1955, shows that plywood is made in two broad classifications, according to intended use, interior and exterior. The major distinguishing characteristic between these two categories is in the type of adhesive used to bond the veneers, although there are different grades of veneers permitted in the two types.

Exterior plywood is almost always bonded with phenolic resin based adhesives which are cured by hot pressing. Interior types are generally made by the cold press, no-clamp process, or by the hot press system using any of several different types of glues. Interior glues are frequently based on proteins in the form of straight soybean flour, mixed soybean flour and animal blood, straight animal blood, urea resins extended with materials such as wheat flour, or with highly extended phenolic resin mixes. These resin mixes sometimes incorporate proteinaceous or amylaceous extenders.

Interior plywood, with which this report is concerned entirely, is required by the DFPA to pass the "Test for Interior Type", par 5.2 of CS 45–55, as modified slightly for production purposes.[3] The latest industry requirements (i.e., what constitutes passing) are outlined in Bulletin No. 2138, issued by the Douglas Fir Plywood Association.

This "Test for Interior Type", frequently referred to as the "M" test or the "10 cycle test", consists of submitting 6 by 6-in. square samples of the plywood to alternate soaking in room temperature water and drying in room temperature air. The plywood is examined for delamination after each cycle, and the number of cycles passed[4] by a sample before delamination occurs is used as the index of glue line quality.

A large number of samples are tested in this way each month by the DFPA and from the results each member mill is kept informed of its production quality. The M test procedure is also used by the DFPA to evaluate new adhesives offered to the plywood industry. An adhesive cannot be used in plywood bearing the DFPA trademark unless it has first been approved by passing performance tests in three different mills under production conditions (3).

Production Standards

The minimum production standards for interior plywood as established by the DFPA require sampling of at least 32 panels per month from a mill, with all specimens (three per panel) showing an overall average of 80 per cent and 85 per cent of all specimens passing at least three cycles without delamination.[5]

The M test serves its purpose in providing a minimum standard for production but it is not unusual to find mills consistently producing interior plywood above the 90 per cent quality

[1] Presented at Session VII, Glues and Gluing, FPRS Ninth National Meeting, June 21-24, 1955, in Seattle, Wash.

[2] Numbers in parentheses refer to Literature Cited.

The Author: H. W. Haigh is a graduate in chemistry from the U. of Washington. He is research group leader, plywood research department, American-Marietta Co.

[3] The DFPA reduced the number of cycles from 10 to 5 in order to make the results available to the mills sooner. A specimen is required to pass all five cycles, however, in computing the score for the mill. If any one specimen does not pass all 5 cycles without delamination, it is scored as a 0. Since three specimens are taken from each panel, this means a panel is scored as 0, 33.33 per cent, 66.67 per cent, or 100 per cent. This procedure was announced in a letter dated July 19, 1949, to all member mills and glue companies. If the panels pass this procedure, it is assumed they will meet the requirements of CS 45-55.

[4] A 6 by 6 in. specimen is said to pass a cycle of the M test if it contains less than a total of 2.5 inches of delamination at least 0.25 in. deep at the end of the cycle.

[5] The over all average is computed under the 10-cycle system as follows: Each 6 by 6-in. specimen from the panel is given a base rating of 100 before testing. The specimen base rating multiplied by the number of specimens tested equals the total base rating of the test. A rating of 10 is given for each cycle a specimen passes. Then the total rating of the cycles passed divided by the total basis rating gives the per cent passing of the test.

rating. For example, one mill showed an average of 92 per cent for cold pressed glue for the last six months of 1954 and the first two months of 1955, while another mill showed a 96 per cent average for hot pressed blood-soy blend glue for the same period. A third mill has averaged 99 per cent for extended resin glues over a six-month period.

This high quality plywood is the result of a gradually improving technology in plywood manufacture and adhesive formulation and is well shown by the increasingly severe requirements of the Commercial Standards. In CS 45–42, which was effective Nov. 16, 1942, all moisture-resistant grades were required to pass two cycles of M testing. This included the concrete form grade. In CS 45–45, which was effective Jan. 27, 1945, moisture-resistant grades of plywood were required to pass only two cycles of the M test, but concrete form grade was required to pass 10 cycles.

In CS 45–47, the requirement was stiffened considerably by classifying all interior plywood under a premium grade and requiring all interior types to pass an average of 10 cycles of the M test.

In the latest revision of Commercial Standards, CS 45–55, under which the industry is now operating, the requirement has become somewhat more severe. The average number of cycles which a sample is required to pass is still 10, but at least 85 per cent of the test pieces must also pass three cycles. This last requirement is aimed at decreasing the number of defective panels.

These high standards which production adhesives are meeting are the same standards which any new laboratory adhesive must meet if it is to become a salable product.

"M" Test as a Laboratory Tool

The laboratory which is developing adhesives to meet these rigid production requirements is sometimes faced with the problem of working with glue bonds which are too good, by existing standards. Insufficient differences in bond quality frequently show up in comparisons of glues evaluated by the M test. Thus, it can happen that after an elaborate gluing experiment in which two or more glues are compared, all or most of the test specimens may pass the M test requirements.

The experimenter then is in a dilemma and must choose from two possibilities: Are the glues truly of the same bonding quality, or are the glues actually different but the test insufficiently severe to show this difference? In using the M test as a laboratory tool for panel evaluation, the latter is frequently the case.

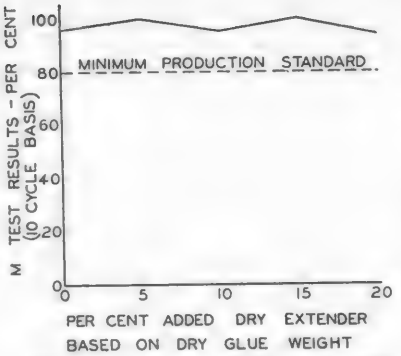

Fig. 1.—Insensitivity of M test to addition of extender. Test is not severe enough to show decrease in bond quality as glue is extended.

To illustrate this insensitivity, an extensive panel experiment was performed using an interior type hot press adhesive. The results are shown graphically in Fig. 1. The panels were laid up over an assembly time range of 3 to 25 minutes, simulating the times used in a mill. On the abscissa is shown the per cent extension of the adhesive. Zero extension means the adhesive was used in its regular composition. Extension was achieved by adding more of the component extender to the glue mix. Additional water was used in sufficient quantity to maintain a constant glue viscosity over the range of extension so that spreading would be controlled.

On the ordinate is shown the M test results (10 cycle basis) by all of the panels made at the corresponding extension and includes all assembly times studied. All panels for all extensions were Douglas-fir and were hot pressed for 4.25 min. at 240° F. platen temperature and at 185 psi. For comparison the minimum production standard is also shown.

It is well known that as adhesives are extended past an optimum point the bonding quality decreases (4). Both water resistance and bond strength are reduced. In this case it can be seen that the M test does not clearly show the decrease in bond quality as the glue is progressively extended. All extensions passed the M test requirements. If an experimenter were comparing the results of panels made with a glue at several levels of extension, he might conclude from this graph that there is no significant difference in moisture resistance between the extended and non-extended glues.

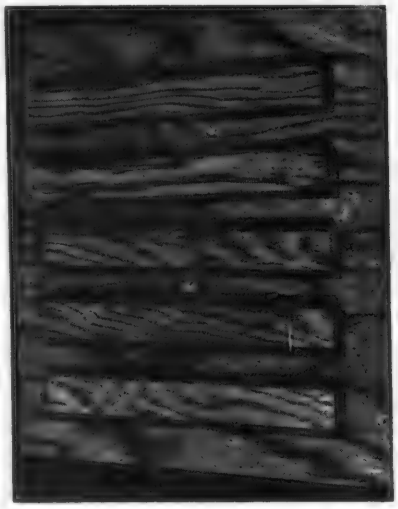

Fig. 2.—Test specimens of Douglas-fir plywood for D test shown in orientation to panel from which cut. Specimen size is 1 by 10 inches. Note that long axis of specimen is cut parallel to grain of face veneer.

Requirements of Useful Test Procedure

To be most useful for plywood adhesive development work, a test procedure should meet certain requirements:

1. The test should bear a close relationship to the use requirements of the plywood.
2. The test should be highly sensitive to the experimental factors when using a small number of samples.
3. The test should give reproducible results.
4. Test results should preferably be available soon so that work can progress continuously.
5. The results should be available in such form as to fit into statistically designed experiments. This is necessary because of the high inherent variability of wood complicated by its sensitivity to manufacturing variables.
6. The test should be sufficiently severe to give some positive failure to most of the specimens studied.

Requirements (2, 4, 5, and 6) above are not met by the present M test.

Description of New Test

A modification of the cyclic M test was studied and found to more closely fulfill the requirements. This method involves the measurement of the actual amount of delamination which takes place when the specimens are alternately soaked and dried. Delamination can be measured with a desk ruler or a small instrument of the type designed for measuring map distances, or it can be simply estimated when one gains experience with the test.

For the delamination test under study, i.e., the D test, a new test specimen was designed. Each specimen consists of a 1- by 10-in. piece sawed from the panel so that the long axis is parallel with the grain of the face veneer regardless of the number of plies in the panel. Fig. 2 shows the proper orientation of the test specimen with respect to the panel.

This shape exposes the maximum amount of end grain of the cross bands, and, since the specimen is only 1-in. wide, ensures rapid saturation during soaking and equally rapid and complete drying of the glue line and cross banding. Rapid saturation and rapid drying of the cross bands are conducive to high stresses across the glue lines as well as rapid delamination. The severity of the stresses is evidenced by the warping and bending of the specimen. This can best be seen directly after a soak period.

Fig. 3 shows three typical test specimens which have remained intact through nine cycles. Note the warped appearance compared to the unsoaked specimens in the same view. Fig. 4 shows similar specimens which have delaminated during 9 cycles of testing.

In contrast to this the author has frequently noticed M test specimens which do not completely dry to the center during the drying period, nor do they become completely wetted during the soak. Some M test specimens have been known to show what appears to be delamination on an early cycle, but the delamination is no longer visible after 9 or 10 cycles. Further, in the M test the relative humidity at room temperature is not subject to control. Drying rates, consequently, may vary widely.

Other changes have been made in the test to increase severity and to increase reproducibility. In contrast with the M test, the soak time is quadrupled (16 hours instead of 4, in room temperature water) and the drying time is reduced from 20 hours at room temperature to eight hours in a forced draft oven at 150° F. The total time for one cycle is still 24 hours, making it convenient to run one cycle per day.

By using elevated temperatures, more rapid drying is achieved and the effect of atmospheric humidity changes on the drying rate is minimized. This means more reproducible drying conditions throughout the cycles. The cycling should be continued long enough to produce definite delamination on most of the specimens.

Advantages of D Test

The D test has other advantages as a laboratory tool. From any panel of a given size a greater length of glue line can be exposed to cycling, in effect increasing the number of variates in an experiment. This improves the reliability of sampling because the results from well-dispersed specimens more closely approach the true quality of the entire panel. For example, in preparing a 14- by 14-in. 3-ply laboratory panel, a maximum of four 6- by 6-in. specimens can be obtained for the M test. These can expose only 192 in. of glue line to cycling. From the same panel eleven 1- by 10-in. specimens can be cut if desired, exposing 484 in. of glue line to cycling.

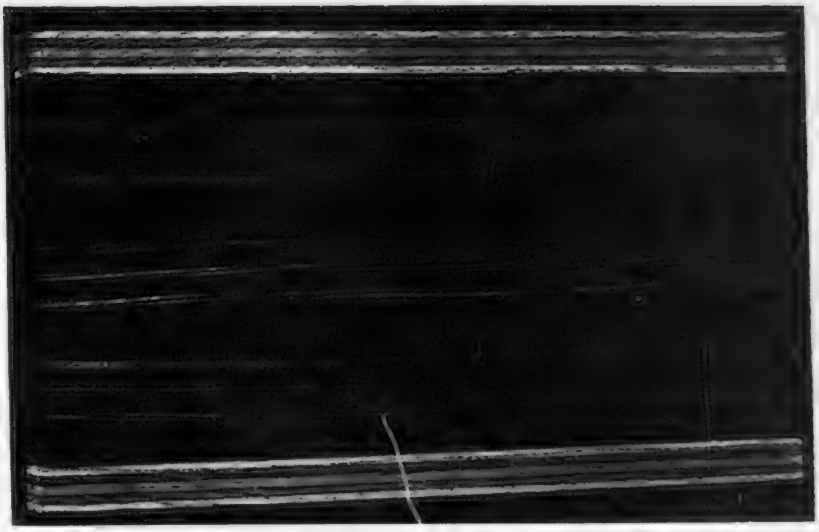

Fig. 3.—Three wet test specimens immediately after completing a soak period of 16 hours in water. The specimens have completed 9 cycles of D test without delamination. Curvature of pieces indicates stresses developed during soaking period.

Fig. 4.—Test specimens which show severe delamination after 9 cycles of D test. The amount of delamination can be measured with a desk ruler or map measuring tool.

When the delamination of individual glue lines is measured, it is possible to note which combinations of stock, such as sap-to-heart, sap-to-sap, heart-to-heart, or which combinations of peel such as tight-to-loose, tight-to-tight, or loose-to-loose, have been coincident with the most failure. This effectively gives more information to the experimenter with no increase in the size of the experiment.

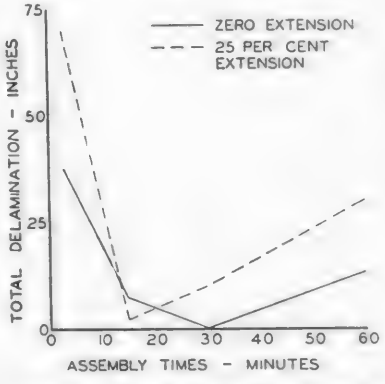

Fig. 5.—Total delamination in D test for two different extensions of interior adhesive. Minimum for each curve is optimum gluing point.

The D test seems to be somewhat more sensitive than the M test to gluing variables such as glue extension and assembly times. Glue technologists are well aware of these effects on glue performance. In general an adhesive, if properly formulated for plywood use, requires a minimum assembly time of about 5 minutes to compensate for loading and closing times of presses.

Applying pressure, or heat and pressure, when the glue is too wet will result in a high flow condition on the panel and the possibility of a starved joint. The opposite of this is a dried-out glue line caused by too long an assembly time before placing the panel under pressure. An ideal adhesive would work well at zero assembly time and just as well at an infinitely long time. If, for a series of panels of varying assembly times, a plot is made of a variable such as M test results, or total inches of delamination, a curve with a definite maximum or minimum should be obtained.

Fig. 5 shows the curves of total delamination in the D test for two different extensions of an interior resin adhesive. The minimum for each curve is the point of optimum gluing. On either side of this optimum the amount of delamination increases.

Fig. 6 shows the M test results for the same panels. In this case the zero

extension adhesive failed to show any assembly time sensitivity, while the 25 per cent extension showed a decrease in M test results only at 60 minutes' assembly time. Fig. 6 is indicative of the lack of assembly time sensitivity of the M test.

Use of D Test in Statistically Designed Experiments

The test method is suitable for experiments in which more than one variable can be studied simultaneously (5). Since more than one variable is always present in a gluing experiment it is advantageous to know the effect of the individual variables and any interactions which may take place between them. An illustration of this statistical technique is as follows:[6]

Suppose it is desired to study the effect of three stock treatments on gluing with an interior adhesive. These treatments could be such variables as density of wood, varying degrees of surface roughness, varying stock moisture content, stock from various geographical regions, various veneer drying conditions, or others. Three-ply panels could be made with faces and cores varied as to treatment. This type of experiment would fit into a randomized block design and could be analyzed by the technique of analysis of variance (5).

A mill run experiment of this type was performed using samples from only 18 panels. The results are presented here to show what information can be obtained, the confidence one may place in the results, and how the new test method may be used to advantage over the M test.

[6] It is presupposed here that the reader has some familiarity with statistical terminology. Two excellent texts on the subject are: Brownlee, K. A., Industrial Experimentation, Chemical Publishing Company, Incorporated, New York (1953); and Youden, W. J., Statistical Methods for Chemists, John Wiley and Sons, Incorporated, New York (1951).

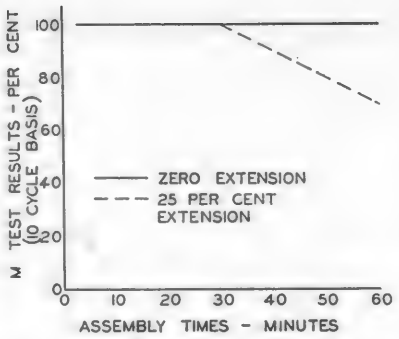

Fig. 6.—M test results for same panels illustrated in Fig. 5. Zero extension failed to show assembly time sensitivity; 25 per cent extension showed decrease in results only at 60 minutes' assembly time.

The experiment was replicated (i.e., performed twice) to give added confidence in the results. This was a two-factor randomized block design, with each factor being run at three levels. Two 1- by 10-in. test specimens were sawed from separated portions of each panel and subjected to soaking and drying as previously described. The total number of inches of delamination of each piece was measured after enough cycles had been completed to obtain some delamination on all but two of the specimens. This gave a range of delamination from 0 to 27 in. The maximum delamination possible on each piece was 44 in.

Fig. 7 shows the overall block design. Each number in a block represents the total inches of delamination of the corresponding test specimen at that combination of treatments. It was suspected from previous work that treatment C would present the most difficult gluing problem, and the experiment was conducted to verify this point.

The mean results for each combination of conditions is shown under each column and at the right of each row. From these means it can be seen that as the panels include more veneer of treatment C type, the amount of delamination increases. The worst gluing resulted when faces and cores were both of treatment C type. The analysis of variance verified the observation that treatment C produced significantly poorer glue bonds than did either A or B in both face stock and core stock. Note the fairly close agreement between the total delamination of the replications.

Fig. 8 again shows the block design but the numbers in this case are calculated according to the accelerated M test of the DFPA[7]. In this case three 6- by 6-in. specimens were taken from each panel and submitted to five cycles of the M test.

A cursory examination of these results shows that panels made with treatment A faces and all three cores are equal and are also the same in performance as the treatment B faces and treatment B cores. Likewise treatment B faces with treatment A core are equal to treatment B faces with treatment C core. In looking at the means for core stock treatments, there appears to be no great difference. The means for face stock treatment indicate some poor performance by treatment C type.

There is some correlation in the two methods in that treatment A faces and cores are among those that produce the best bonds, but treatment C face stock produces the poorest bond; the variability between replications disturbs the confidence one has in the averages shown.

The M test results were also submitted to an analysis of variance, and the results confirmed the observations discussed above.

A dependence on the M test results of this experiment would lead to the conclusion that core treatment has no effect on the gluing. Such a conclusion is directly contrary to the D test results

[7] DFPA letter dated July 19, 1949. See footnote 3.

FACE STOCK TREATMENT

CORE STOCK TREATMENT		A Rep. 1	A Rep. 2	B Rep. 1	B Rep. 2	C Rep. 1	C Rep. 2	Total	Mean in. Delam.
	A	2	0	7	2	12	12	64	10.7
		4	2	1	1	8	13		
	Totals	6	2	8	3	20	25		
	B	1	3	1	3	15	8	66	11.0
		0	6	5	2	13	9		
	Totals	1	9	6	5	28	17		
	C	10	14	10	16	25	7	153	25.5
		3	7	8	9	27	17		
		13	21	18	25	52	24		
Total		(52)		(65)		(166)			
Mean (in Delam.)		8.7		10.9		27.7			

Fig. 7.—Effect of three stock treatments on gluing with interior adhesives measured by D test. Results show how D test can be used to advantage over M test.

FACE STOCK TREATMENT

CORE STOCK TREATMENT		A Rep. 1	A Rep. 2	B Rep. 1	B Rep. 2	C Rep. 1	C Rep. 2	Total	Mean (Percent Passing 5 Cycles)
	A	100	100	67	100	67	67		
	Totals	200		167		134		501	83.5
	B	100	100	100	100	0	33		
	Totals	200		200		33		433	72.2
	C	100	100	100	67	0	100		
	Totals	200		167		100		467	74.5
Total		600		534		267			
Mean (Percent Passing 5 Cycles)		100		89		44.5			

Fig. 8.—M test results for same panels illustrated in Fig. 7. Variation between replications lessens confidence in averages.

and to past experience in the laboratory and the mill alike.

There is a question as to the validity of making a complete analysis of variance calculation, using the M test data, because of a doubt that M test results conform to the normal probability curve. M test data were tested for distribution in several experiments. In every case the curve showed an abnormal distribution. A logarithmic transformation of the data failed to produce a log normal curve. Data from the D test, however, was transformable.

Summary

A laboratory test method for interior plywood has been presented and comparisons made with the present cyclic moisture test as outlined in the Commercial Standards for Douglas-fir plywood. In this comparison some advantages of the new test have been shown:

1. The method is applicable when statistical evaluation of the results is desired.
2. The method is more sensitive to two major gluing variables—glue extension and assembly times.
3. The test is inherently more severe than the 10-cycle test because it provides greater glue line stresses due to the shape of the specimen. Because of these severe stresses, results can frequently be made available to the experimenter in a short time.
5. The test is closely related to the use requirements of plywood and it gives a numerical index of delamination.
6. Because of the more closely controlled drying conditions and because the specimen size permits increased sampling of small panels, it is expected that the test will prove more highly reproducible. Therefore, it will be valuable as a means for the evaluation of laboratory experiments directed toward improving the quality of interior type plywood adhesives.

Literature Cited

1. Ripley, Robert H. 1953. Effective quality control on end product. Jour. of F. P. R. S. III (5):25.
2. Commercial Standard for Douglas Fir Plywood. CS 45-55. U. S. Dept. of Commerce.
3. Douglas Fir Plywood Assoc. Bull. No. 2138.
4. Brouse, Don, and Blomquist, R. F. 1947. Postwar developments in woodworking glues. Proc. F. P. R. S. p. 85.
5. Bryant, Ben S. 1954. Reducing the high cost of information by using the statistical approach to research. Jour. of F.P.R.S. IV (5): 322–325.

Discussion

William Martin (Harbor Plywood Corp.): What type of adhesive was used in this experiment? Was it a blood type?

Mr. Haigh: Yes. It was a blood-based hot press adhesive.

Robert C. Raymond (D. F. P. A.): Do you consider sensitivity as necessary for quality control as for lab research work?

Mr. Haigh: I think that for purposes of pure quality control and of minimum production standards it won't be completely necessary. This test was developed for laboratory work.

George G. Marra (Washington State Institute of Technology): Sensitivity does pay off in production testing. It permits you to get a high level of confidence with minimum testing and consequently minimum cost.

A New Type Screened Dryer for Rotary Peeled Veneers[1]

J. W. GOTTSTEIN and D. M. CULLITY

Senior Research Officer, Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne; and General Manager, Westralian Plywoods Pty. Ltd., Perth

Describes a new compartment type cross circulation dryer which incorporates a combined screen and straightener. The unit should have wide range of application in Australian veneer and plywood industry under present conditions because of resulting fast drying times, improved dried veneer quality, and favorable economy. Economic factors and properties of species used in U. S. and other countries might necessitate some alterations.

FOR MANY YEARS the major proportion of green rotary veneer peeled in Australia has been dried in the open air. This is in contrast to practice in most other countries.

Air drying with the veneer racked vertically in horizontal fingers has proved economical, both in labor and installation costs under the prevailing climatic conditions. Drying time in good drying weather has ranged from one to three days for 1/16-in. veneer, and dried quality has usually been good with a minimum of splits and buckling.

More recently, however, drying time and moisture content control have become increasingly important, particularly the latter, since synthetic adhesives are often hot-pressed well above 212° F. and low veneer moisture contents are essential.

Roller and mesh belt mechanical driers have been used successfully, but installed cost per unit output is relatively high, especially for the comparatively small plants common in Australia. On the other hand, counter flow, progressive, and compartment kilns using the economical vertical racking have not been entirely successful when drying green veneers because of the frequency of splitting and buckling. These difficulties led to a study of the factors involved and ultimately to the development of the C.S.I.R.O. Cross Circulation Screen Drier.

It has been shown (7)[2] that at air velocities between 100 and 1200 ft. per minute and flow parallel to the surface, the evaporation rate from a wet surface is roughly proportional to increasing wet bulb depression, only slightly affected by temperature, and is approximately proportional to the

[1] Presented at Session II, Wood Drying, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

The Authors: J. William Gottstein received B.S. from U. of Queensland. He was with Queensland Forest Service from 1928–41; conducted testing and research at Engineering Dept., U. of Queensland, from 1941–44; has worked on development of seasoning techniques for CSIRO since 1944.

Denis M. Cullity is graduate of U. of Western Australia. He was technical officer with Div. of Forest Products, CSIRO, from 1949–50, joined present firm in 1951 and was appointed general manager in 1954. He has been member of FPRS since 1950.

[2] Numbers in parentheses refer to literature cited.

0.8 power of air velocity, v, although various workers have given figures between $v^{0.6}$ and $v^{0.9}$.

Earlier work (1, 2) had shown the importance of air velocity in ash eucalypt veneer drying and had found that the interior of 1/16-in. ash veneers, tested with fine wire thermocouples, remained near wet bulb temperatures in the early stages of drying under moderate air flow rates. Further confirmation of this temperature behavior was obtained in 1/16-in. veneers of a number of species in subsequent unpublished laboratory experiments conducted by Christensen and Gottstein in 1951.

Excessive emphasis should not be placed on the temperature results, however, because evaporation within the material and poor heat transfer between surface and inner layers could maintain low temperatures. A marked improvement in drying rates was obtained by increasing air velocity leaving all other factors constant. This showed that capillary moisture transfusion in green veneers must be sufficiently rapid to maintain a comparatively moist surface for some time, although there was evidence that the falling rate drying conditions of Sherwood (10) are probably established fairly early in the drying period.

More recent confirmation of the importance of air velocity in affecting the drying rates of thin wood specimens or veneers has been given by Fleischer (3) and by Keylwerth (6). Similar results were also obtained by Higgins (5) in the air-drying of paper.

Field studies carried out by one of the authors in 1949 showed that air velocities in both cross-circulation and counter-flow progressive kilns using vertical racking varied considerably in the drying zone. As a consequence, temperatures were also subject to considerable variation. It was thus apparent that greater uniformity of air flow, together with its consequent effect on temperature, is an important factor in the quality of drying obtainable.

The air distribution in the cross-circulation (overhead fan) units tested followed a fairly uniform pattern of rapid flow towards the bottom of the drying chamber, eddying or almost stagnant conditions in the middle portion of the drying zone, and a sluggish to a fairly rapid reversal of flow towards the top of the chamber. This flow pattern was, of course, completely different from that existing in cross-circulation units containing stripped (stickered) timber stacks or veneer trays, both of which provide appreciable resistance to air flow and tend to equalize the distribution as a consequence. The air distribution in the counter-flow progressive dryers followed a rather different pattern, with high velocities along the sides, top, and bottom of the charge.

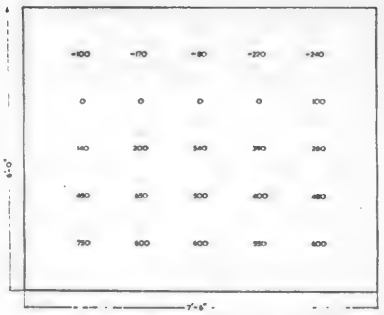

Fig. 1.—Air flow in feet per minute over longitudinal section of charge space of laboratory kiln on air inlet side without screen. Figures are given at test positions. Note—minus values show air flow reversal.

It was decided, therefore, to carry out a laboratory investigation of air flow in the cross-circulation kilns to determine possible methods of improvement.

The compartment unit available was equipped with two 24-in. diameter flat-bladed reversible propellor type fans, side spaces 20 in. wide and a charge space 7½ ft. long, 6 ft. high, and 4 ft. wide. Rates of air-flow were tested with a Metrovick velometer accurate to approximately ± 5 per cent.

The general air flow pattern in the empty chamber conformed closely to that observed in commercial units using vertical finger racking. The air flow results in feet per minute are shown in Fig. 1. Methods of improving air velocity distribution in the charge space were considered, including precautions against sudden velocity changes, the provision of fan straighteners (9), suitably smoothed corners with turners (11, 8), and screens, but these would have caused the cross-section of the unit relative to the drying zone to become excessively large.

It was also felt that heat distribution, particularly under part load conditions and high ventilation rates, might be unsatisfactory. In addition,

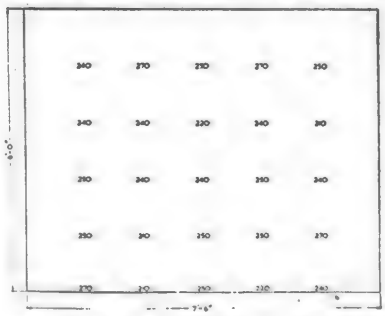

Fig. 2.—Air flow in feet per minute over longitudinal section of charge space of laboratory kiln taken in same position as Fig. 1, but double screen with 1-in. strips at ¼-in. spacing installed at inlet to charge space.

varying veneer sheet lengths in the drying zone might tend to upset distribution under the carefully balanced flow conditions. Alternatively, even though "egg crate" straighteners and a simple screen of suitable design on each side of the drying zone could provide suitable correction with some static head loss, they would still occupy appreciable space.

It was finally decided to carry out experiments with a screen which would provide velocity correction and also straightening in the horizontal plane and to depend upon the vertically racked veneers to provide straightening in the vertical plane. A screen straightener device was developed consisting of 1-in. square planed strips of dry pine, spaced horizontally at intervals on vertical studs. This was placed between the kiln side space and the drying zone. The wooden strips were mounted on one side only and also on both sides of the studs and tested at various spacings. The air flowing between the strips diverged satisfactorily at an included angle of about 15° so that flow appeared quite uniform a few inches from the screen.

The double screen with horizontal strips mounted on both sides of the studs proved more satisfactory than the single, taking little more space and giving slightly better distribution for the same total head loss. This presumably was because two smaller adjustments to the air flow provide a smaller total disturbance than a single large correction.

Several adjustments to the thickness of the supporting studs were found necessary to avoid excessive break-away in flow. In the laboratory trials the critical stud thickness was approximately 1¼ in.; at and below this thickness the break-away did not occur. It was considered that the ducts formed by the vertical sheets and horizontal fingers would assist in maintaining uniform flow once this was established. However, in order to provide for fan reversal during drying, a screen on each side of the charge space was necessary. It was anticipated the racked charge would have a sufficiently low resistance to flow and that the distribution established by the screens would not be seriously upset by it.

In the laboratory kiln at an air velocity of a little more than 240 ft. per minute, a screen strip spacing of approximately ¼ in. provided improved circulation in the charge space correct to ± 10 per cent for a total static head loss of approximately 0.17 in. water gauge (Fig. 2). The actual head loss in a screen and straightener of this type can be anticipated fairly accurately from data published by

Greenhill (4). Fig. 3 shows screen test results compared with a smoothed curve drawn through Greenhill's data.

Experimental drying of vertically racked 3-ft. square veneer sheets was then undertaken. The drying conditions chosen were wet bulb temperatures of 90 to 100° F. and wet bulb depressions of 50–60° F. as found satisfactory by Ellwood (2) for the collapse susceptible ash type eucalypt veneers.

These conditions were chosen as the most promising for several reasons. First, because of the fairly rapid drying potential of the schedule; second, because of possible application of the method to collapse susceptible species in which high wet bulb temperatures increase collapse; and third, because low temperatures in the initial drying stages should assist the veneers to remain in a reasonably firm condition and keep buckling at a minimum in the rather limited restraint possible when simple horizontal finger support is used. The higher veneer temperatures obtained towards the end of drying would also be useful in assisting moisture transfusion in the thicker veneers and more impervious species.

The dried quality of the veneer was very good, with little buckling and no splitting in a large number of fairly straight-grained medium density species of the diffuse porous type, common to the Australian plywood industry. Drying times varied from 30 to 60 minutes for 1/16-in. veneers, according to species and initial moisture content. Final moisture contents were uniform, although, of course, the leading edge of the sheets dried more rapidly than the remainder because of the high energy transfer near the point of air entry.

The results made it clear that the moderate schedules being used in many commercial kilns were dictated by the deficiencies of the drying unit, rather than by the limiting drying characteristics or most suitable schedule conditions for vertically racked veneers.

The equipment available did not permit trial of more severe schedules, but there was no reason to believe that the schedule adopted was a limiting one for vertical racking.

Limited studies were then undertaken to determine a suitable spacing for the veneer sheets. With 3 ft. x 3 ft. green veneer sheets spaced 2 in. apart, the air temperatures on the air discharge side of the drying veneers were dtermined with fine wire thermocouples. At flow rates of 200–250 f.p.m. and schedule conditions as outlined earlier, the temperatures in the center of the 2-in. duct (i.e., 1 in. from the faces of the veneers) were more than 5° F. higher than those

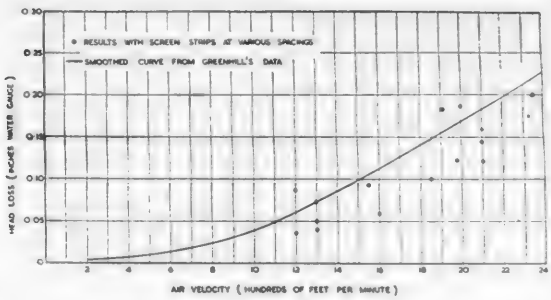
RESULTS WITH SCREEN STRIPS AT VARIOUS SPACINGS
SMOOTHED CURVE FROM GREENHILL'S DATA
HEAD LOSS (INCHES WATER GAUGE)
AIR VELOCITY (HUNDREDS OF FEET PER MINUTE)

Fig. 3.—Approximate pressure loss across single screen based on mean air velocity between strips with spacings from ¼ in. to 1 in.

approximately ⅛ in. from the veneer surface. This result was presumably due to the comparatively limited turbulence and rather thick boundary layer present at this velocity.

Increasing the air flow to 400 f.p.m., which was the limit of the equipment available, provided a definite improvement in temperature distribution across the duct, but did little to improve temperature drop along its length. These results confirmed the opinion that it is necessary to use fairly high air velocities, together with the shortest air path and maximum sheet spacing economically possible, to maintain rapid and uniform drying.

Where sheets are closely spaced and only lightly supported, any slight buckling which occurs tends to restrict circulation. This results in slower drying and slower shrinking in the restricted area. This in turn accentuates the buckling. The sheets may then come into contact and, by blocking the circulation, delay drying considerably. In the later stages, when the delayed zone eventually dries, severe tension may develop in the surrounding area and cause distortion and, in some cases, splitting of the sheet.

The data obtained from trials of different sheet spacing and species led to the conclusion that, for vertical racking, sheet spacing should be not less than 2 in. and that 2½ was probably a preferred minimum.

The results of these experiments showed clearly that a cross circulation kiln using the screen straighteners could be constructed economically and should be an effective drier for green veneers. The design of a commercial unit was accordingly given consideration.

Design of Commercial Units

General: The most urgent commercial requirement was for a cross-flow compartment type unit 26 ft. long, with a charge capacity of 240 sheets, as shown in longitudinal section in Fig. 4 and in cross-section in Fig. 5. This was designed for double width kiln trucks holding 90-in. x 42-in. veneer sheets. The results with this prototype were so satisfactory that a similar 26-ft. long compartment unit suitable for drying veneers 102 in. x 58 in. has since been constructed at the same plant.

The screened design can be used for any desired kiln length appropriate to production and layout. It is equally applicable to cross-flow progressive units where this is convenient. If factory conditions warrant, a moisture equalizing zone can be added for accurate adjustment of final moisture content after drying.

The screen dryer does not possess special technical advantages compared with roller or mesh belt mechanical units, since in these the veneer movement compensates automatically for minor deficiencies in circulation and temperature distribution.

Circulation: The pressure losses in the screens and unit as a whole were found to be well within the capacity of low cost, flat-bladed reversible type propellor fans. Circulation rates exceeding 500 ft. per minute were obtained in the charge space with a total head loss of less than 0.5 in. water gauge. Using cross shafts, the fans are driven externally either singly or in groups. Equipment for reversing must be installed.

Recent commercial trials have shown an improvement in drying rate with air circulation at about 700 f.p.m. and this is probably justified where suitable fans are available. To overcome the rather high static head inherent in using this velocity, power consumption is inevitably high, especially with reversible flat-bladed propellor fans. The circulation distribution on the air inlet side of the most recent unit is shown in Fig. 6.

Heating: The large evaporation rates obtained in the experiments made it clear that it would be difficult to secure the necessary heat transfer with unfinned steam pipes. Single row finned unit heaters, which would permit somewhat more severe conditions than available during the laboratory tests, were adopted and have proved entirely satisfactory. To insure temperature uniformity, little air by-pass

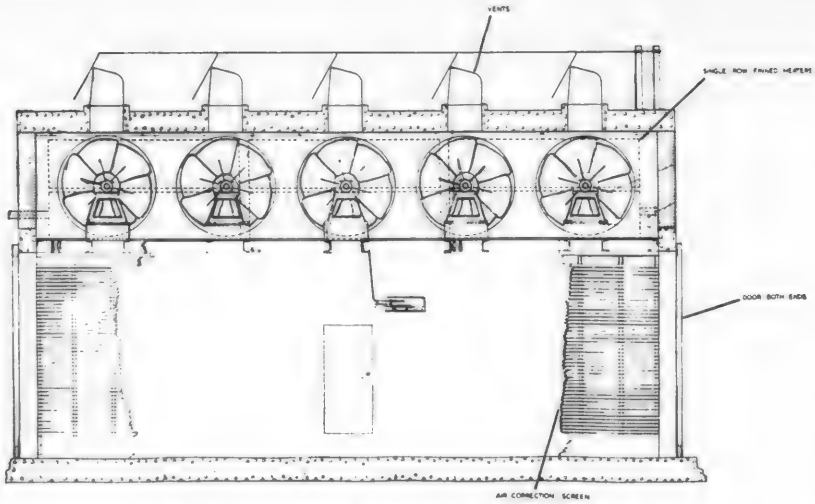

Fig. 4.—Longitudinal section of C.S.I.R.O. Screen Dryer.

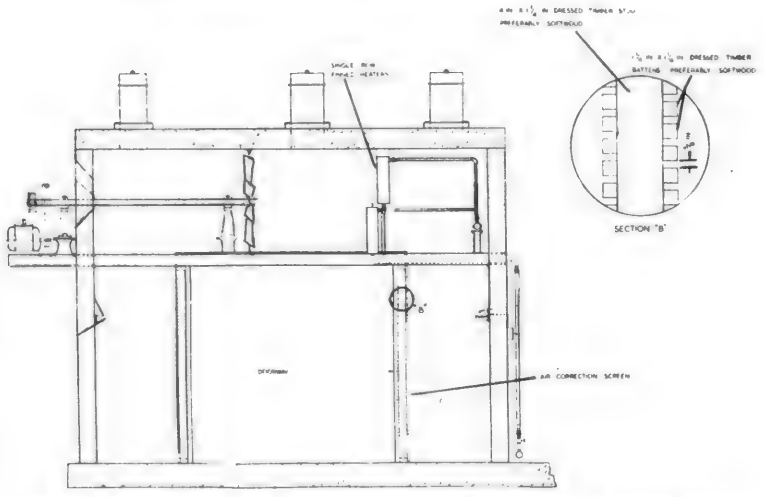

Fig. 5.—Cross section of C.S.I.R.O. Screen Dryer and details of double screen.

of these heaters is used. The design was adjusted so that heaters would operate at about 0.1 in. water gauge head loss.

Ventilation: Vents were designed to maintain wet bulb temperatures between 110° and 120° F. even at dry bulb temperatures of 180° F., and heat losses through ventilation are thus comparatively high. Three vents per fan, forming three rows of vents instead of the usual two of cross-circulation kilns, were adopted in conjunction with the single row finned heaters. Vents in each row are linked together. The third row of vents takes advantage of the pressure drop across the heaters and permits vent settings to exhaust only that air which has passed through the drying charge.

The actual ventilation losses are indicated in Fig. 7, and are based on psychometric data published by Zimmerman and Lavine (12). The losses are shown for intake air at 60° F. dry bulb and 50° F. wet bulb and for various spill temperatures.

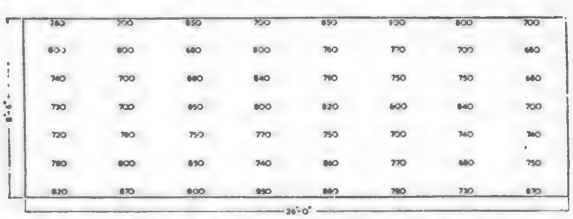

Fig. 6.—Air flow in feet per minute over longitudinal section of charge space on inlet air side of commercial kiln for 8-ft. x 4-ft. sheets.

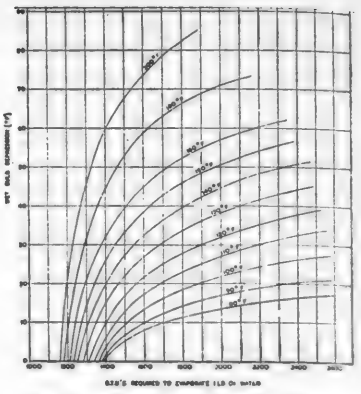

Fig. 7.—Heat required for evaporation and ventilation under normal operating conditions with air intake at 60° F. dry bulb and 50° F. wet bulb and spill conditions as shown on curves.

In considering these losses, it must be noted that the dry bulb temperature of the exhausted air is 20°–30° F. below the nominal schedule condition in the early stages of drying but not in the later stages. The comparatively large spill of air could be used to heat intake air if desired and some heat economies could be effected, but this has not so far been considered in detail for the design since adequate waste or low cost fuel has usually been available at veneer plants.

Screens: The double straightener screens, as developed in the laboratory, were adopted. These are based on 1¼-in. square strips, set at ⅝-in. spacing, as shown in Fig. 5. This final setting was determined by field tests since the combination of fan, heater, side space, and kiln proportions all influence the resistance necessary to provide adequate circulation correction. The top of the screen should coincide with the top of the longest veneer sheets, and the area between screen and sub-ceiling must be closed, as must the area below the veneer sheets.

A view of the screens inside an 8 ft. x 4 ft. sheet kiln is shown in

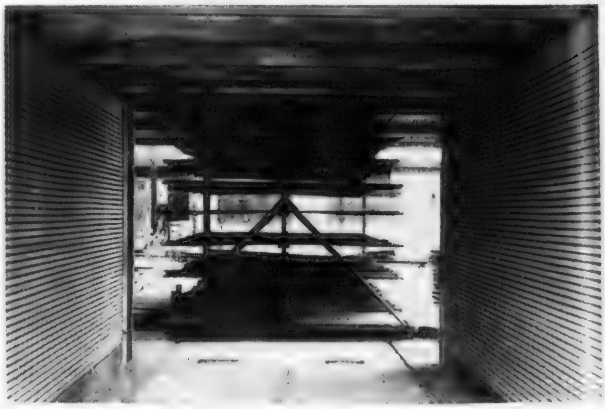

Fig. 8.—View of screens inside an 8-ft. x 4-ft. sheet kiln. An empty veneer truck is in the background.

Fig. 8. An empty veneer truck can be seen in the background.

Construction: Constructional materials are generally not critical because of the moderate temperatures and comparatively uniform drying conditions used. Plywood or asbestos-cement is suitable for sub-ceilings and fan shrouds. Walls and roof may be in masonry or concrete, or even insulated metal panels if desired. Insulation requirements should be considered for each particular application, but, because of the moderate temperatures of operation and the climatic conditions prevailing, are not usually important under Australian conditions.

Simple roller track type hangers carrying light-weight doors without special seals are satisfactory since the kiln is practically at atmospheric pressure throughout the drying zone.

The high wet bulb depression and moderate temperatures used cause little corrosion in fan joists, fans, and fan shafts, and an occasional coating with a corrosion resistant paint is all that is required.

Controls: The dry bulb temperature control needs little attention and can be set manually without difficulty. Automatic control may be preferred when steam economy is important.

Wet bulb temperatures are maintained fairly well by pre-determined manual setting of the vents but can be kept under automatic control if so desired. This will also result in additional steam economy where this is required and minimize necessary supervision.

Capital Cost and Capacity

Factors which influenced the decision to install the screened kiln in preference to a mechanical roller or mesh belt drier were the low initial capital cost, ease of construction using untrained personnel, and the small number of moving parts with consequent ease of maintenance.

Two kilns are at present in operation at the plant where the prototype was installed. The total cost, including kiln trucks and friction winch for loading and unloading was £A8,000 or roughly $17,800.

The capacity of the two kilns on a 24-hour basis, one drying nominal 8-ft. x 4-ft. sheets and the other 7-ft. x 3-ft. sheets of 1/16-in. ramin *(Gonystylus sp.)* veneer is 600,000 sq. ft. The evaporate capacity of the two kilns is about 80,000 lb. of water per 24 hours.

With its higher air velocity the 8-ft. x 4-ft. sheet kiln gives a rather faster drying rate than the one taking 7 ft. x 3 ft. sheets and its daily capacity is over 400,000 sq. ft. of 1/16 in. ramin veneer. The above outputs are on the basis of net finished veneer size after the veneer has been pressed into plywood and trimmed. On the basis of 1/16 in. ramin, the unit cost is approximately £A0.3 per sq. ft. of dried veneer output per hour.

Fig. 9.—Empty double width veneer truck for 7-ft. x 3-ft. sheets.

Mechanical dryers are not manufactured in Australia but, as a comparative figure, the price of imported dryers from Germany and the United States varies from £A1–£A3 per sq. ft. of 1/16-in. veneer capacity per hour.

Loading the Kiln

Two slightly different systems of loading and unloading the kilns have been tried. For the kiln designed for 7-ft. x 3-ft. sheets, double width trucks each measuring 8 ft. x 4 ft. were constructed of timber with steel bracing. Each was equipped with six full swiveling cast iron wheels. Each truck was fitted with six sets of horizontal fingers in vertical alignment and approximately equidistantly spaced over a total height of seven feet (see Fig. 9).

Six trucks of green veneer are aligned on a center guide track on the green end of the kiln. When the drying of the previous charge has been completed, the doors of the kiln are opened front and back. The dry trucks are coupled to the green charge behind them and in one operation, with the aid of a friction winch, the kiln is unloaded and reloaded. The six dry trucks are then individually taken to an unloading bay, unloaded, passed on for reloading, and then lined up in the guide again at the green end of the kiln. Eighteen trucks were originally provided to allow for six spares at all times.

The original intention was to provide some 36 trucks so that the 30 outside the kiln at any given time could be transported to a preliminary air drying site. The kiln so exceeded expectations that this was found to be unnecessary.

A more simplified handling procedure has been adopted for the 8-ft. x 4-ft. sheet kiln. Two large trucks have been constructed using steel channels for the chassis frame and uprights. Each truck measures 26 ft. x 10 ft. 6 in., the uprights being 8 ft. 6 in. high. The trucks are provided with seven sets of horizontal fingers in vertical alginment (see Fig. 8). A single set of rails runs through and extends 40 feet beyond the kiln at each end. The kiln trucks are coupled together in tandem and are pulled in and out of the kiln by a friction winch with reversible drive and the rope counter-wound in two sections on the drum. They are therefore unloaded and reloaded alternately at opposite ends of the kiln, and one is unloaded and reloaded while the other is drying.

Veneer Handling Efficiency

Racking veneer vertically is a long established practice in Australia. A high degree of efficiency has been achieved and much thought has been given to methods of speeding up the process. Operators have found no difficulty in practice in aligning the veneers in the corresponding vertical fingers.

Using nominal 7-ft. x 3-ft. sheets (gross dimensions 89 in. x 41 in.) operators can load at the rate of 4,000 sq. ft. of veneer per man hour and unload at the rate of 8,000 sq. ft. per man hour. The kiln for 8 ft. x 4 ft. sheets was given its first trials in April 1955 and sufficient data are not yet available to make any definite statements regarding man hour racking performance.

The horizontal fingers were constructed of 5/8-in. electrical conduit flattened on the ends. The ends of each pair of conduits were bent together and welded giving fingers 1¾ in. wide with ½-in. spacing between. The welding was alternated at one end of the conduits with reference to the other to minimize any boundary layer effect on the sheets on the trailing side of the truck. The conduits were clamped in position in the center of the trucks.

Operation of the Kiln

The time required to kiln dry the veneer to slightly less than 8 per cent. was initially determined by experiment. Temperature differentials in the side ducts also gave a reasonably accurate indication. From data contained in Division laboratory records, it has been shown that for a given set of kiln conditions and a known species and thickness, the difference in temperature readings between thermome-

ters placed in the ducts is related to the moisture content of the dried veneers. This method is being refined and an alarm has been built to indicate automatically when the veneer is dry.

Dried Veneer Quality

The screen dryers, incorporating improved air flow characteristics and greater drying potential, have successfully overcome both end frilling and splitting and have enabled the use of rapid drying potential schedules which are necessary for at least the collapse susceptible veneers.

In the kiln for 7-ft. x 3-ft. sheets, 6-ft. and 5-ft. long veneers are dried with equal success and baffling is not required at the top of the kiln for the shorter sizes. Final moisture content and distribution have proved satisfactory.

Two species, ramin and karri *(Eucalyptus diversicolor)*, have been dried at a schedule of 160° F. dry bulb, 100–110° F. wet bulb, and the ramin dried well under these conditions. Recent field studies have indicated that karri behaves more satisfactorily at 180–200° F. dry bulb and 100–120° F. wet bulb. With these conditions no trace of internal or face checking in veneers up to 1/10 in. thick has been observed. Further research into schedule effects on species, species quality, thickness and sheet restraint would be valuable.

With cross grained veneers, the vertical racking has resulted in a slight

Fig. 10.—Truck load of 6-ft. x 3-ft. x 1/16-in. dry ramin veneers.

increase in buckling compared with that obtained in trays but the degree of buckling in the species used has not been sufficient to cause production difficulties (see Fig. 10). Veneers from 1/28-in. to 1/8-in. thick are being dried successfully in the new units. The 1/8-in. and 1/10-in. veneers generally dry flatter than 1/16-in. and 1/28-in. material.

Conclusion

The design features of the C.S.I.R.O. Cross Circulation Screen Dryer insure substantially uniform air velocity on vertically racked veneer and provide for a schedule of high drying potential.

Good dried quality is obtained in drying green veneers of many species in units of low capital cost, operation is economical and maintenance costs are low.

Literature Cited

1. Ellwood, E. L. 1950–51. Basic studies on the drying of ash Eucalypt veneers. (1st-2nd Reports) S.7–8: Prog. Repts. 10–11.
2. Ellwood, E. L. 1952. Seasoning of rotary peeled veneer from Eucalyptus regnans F.v.M. *Aust. J. Appl. Sci.* 3:53.
3. Fleischer, H. O. 1953. Drying rates of thin sections of wood at high temperatures. Yale University, School of Forestry. Bull. 59.
4. Greenhill, W. L. 1937. Relation between air flow and pressure change across stack of timber. *J. CSIR* 10:33.
5. Higgins, J. J. 1952. The air-drying of paper. *Tappi* 35:93.
6. Keylwerth. 1954. Furnier-trocknungsversuche. *Holz als Roh und Werkstoff* 11(1):11.
7. Lurie, M. and Michailoff, N. 1936. Evaporation from free water surface. *Indus. and Eng. Chem.* 28(3):345.
8. Patterson, G. N. 1937. Corner losses in ducts: factors affecting the design of efficient corners and leading to reduction of resistance. *Aircraft Engineering* 9:205.
9. Patterson, G. N. 1944. Ducted fans, effect of the straightener on overall efficiency. Aust. Counc. Aeronautics. Report ACA–9.
10. Sherwood, T. K. 1929. The drying of solids. *J. Ind. & Eng. Chem.* 21:12.
11. Wirt, Loring 1927. New data for the design of elbows in duct systems. *G. E. Review* 30:286.
12. Zimmerman, O. T., and Lavine, I. 1945. Industrial research service, psychrometric tables and charts. Industrial Research Service, Dover, N. H.

A Non-Destructive Test of Glue Bond Quality[2]

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A new method for the non-destructive evaluation of glue bond quality by means of vibrational testing is described. By means of an electrical-acoustical system for exciting and detecting vibration, accurate measures were obtained of the resonant characteristics of laminated material. Results showed that relatively small glue line defects of types that commonly occur in laminated material could be detected.

RAPID TECHNOLOGICAL ADVANCEMENTS in industry, particularly in the realm of new product development, have brought about an increasing need for accurate inspection and quality control. The wood industry has been prompt in meeting this need. For the most part, however, the measures taken have been limited to evaluation on the basis of external characteristics. Dimensional control standards for veneer and other wood products and visual grading of lumber for quality are some of the more prominent examples. No one can deny that such controls are valuable and necessary. In today's competitive market, however, more searching inspection techniques are required.

The glue bond quality of wood laminates cannot be ascertained by visual inspection alone, and the technologist concerned with quality control has consequently turned to the destructive testing of selected samples to provide the necessary measure of bond quality. Valuable as such tests have been, there nevertheless exists today a definite need for more precise and non-destructive means of evaluating the quality of laminated wood products. In recent years the non-destructive testing of

[1] Winning paper in Graduate Division, 1955 Wood and Wood Products Award, presented by Vance Publishing Co., Chicago. Paper presented at Session VII, Glues and Gluing, FPRS Ninth National Meeting, June 21-24, 1955, in Seattle, Wash.

[2] The research reported in this paper is part of a study conducted at the Yale School of Forestry for the Springfield Ordnance District, Department of the Army, under Contract No. SAR/DA-19-059-ORD-1329, Project No. TS2-2015. *Development of Non-destructive Tests for Laminated Gunstock Blanks.*

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wood and wood products, particularly with respect to vibrational methods, has received considerable attention. Although developments of this quality measure have been confined primarily to the laboratory, the relative ease and rapidity of its application are attributes which lend encouragement to its potential use in a production scheme of inspection.

Studies of vibrational properties of wood have been concerned primarily with measurements of resonant and damping characteristics at one or more harmonic frequencies. A system is considered to be in a reasonant state when its amplitude of vibration reaches a maximum as a result of an external periodic force acting upon it at the same frequency as the natural frequency of the system.

A laminated wood specimen, considered as a system, has several natural frequencies termed harmonics in both its longitudinal and flexural modes. It follows that each of these frequencies is termed a resonant frequency and is qualified by the mode of vibration—flexural or longitudinal—and the harmonic at which it occurs.[3] The damping capacity of a system can be measured by: (1) complete removal of the exciting force, or (2) slight variation of the periodic force which excites a system and maintains it in oscillation. Complete removal of the exciting force results in the free decay or natural damping of the vibration of the system. This free decay is logarithmic. Consequently, a ratio of the amplitudes of any two successive oscillations leads to a measure of damping and is called specifically the logarithmic decrement (δ).

In equation form:

$$\delta = \ln \left(\frac{A_1}{A_2} \right) \qquad (1)$$

or more generally

$$\delta = \frac{1}{n} \ln \left(\frac{A_1}{A_n} \right) \qquad (2)$$

where A_1 and A_2 are the amplitudes of two successive oscillations and A_1 and A_n the amplitudes of two oscillations n cycles apart. This phenomenon is shown graphically in Fig. 1 (A).

Slight frequency variation of the periodic exciting force will cause the vibrational amplitude of an oscillating system to decrease. This is shown graphically in Fig. 1 (B) where the peak amplitude of vibration occurs at the resonant frequency. Damping[4], as

[3] The lowest natural frequency or fundamental frequency is termed the first harmonic and successive harmonics are numbered in ascending order as second, third, fourth, etc.

[4] This is not strictly natural or free damping since the periodic exciting force is slightly out of phase with the oscillating system at frequencies other than resonance and consequently causes a small amount of external damping.

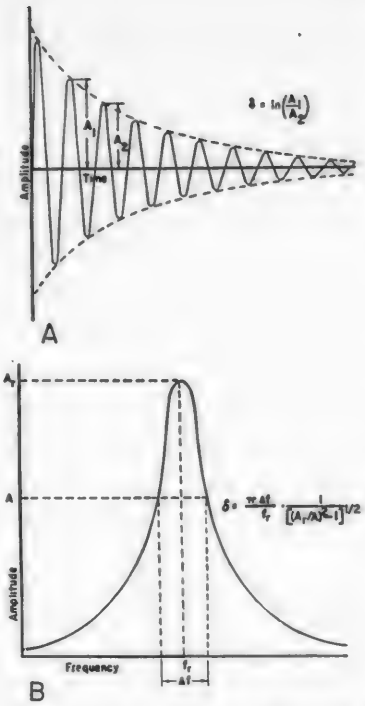

Fig. 1.—Two methods for determining the logarithmic decrement: (A) from measurements of vibrational decay, and (B) from measurements of the frequency response curve.

measured again by the logarithmic decrement, can be evaluated from this curve by means of the formula:

$$\delta = \frac{\pi \Delta f}{f_r} \cdot \frac{1}{\sqrt{\left(\frac{A_r}{A} \right)^2 - 1}} \qquad (3)$$

where f_r is resonant frequency (cycles per second) for the mode of vibration and the harmonic frequency employed, Δf is the width of the frequency response curve (cycles per second) at a response amplitude A, and A_r is the response amplitude at resonance. The width of the frequency response curve is most frequently measured at half-power points (.707 A_r) or half-amplitude points (.500 A_r), since using either of these points permits reducing equation 3 to a simplified form.[5]

Review of Past Work

Physicists and engineers have used vibrational studies to evaluate dynamic Young's modulus,[6] a measure of stiffness, since the early 19th century.[7] Regardless of the material under test, providing it has elastic properties, fundamental relationships exist which relate dynamic Young's modulus in bending to the resonant frequency of a flexural mode and dynamic Young's modulus in compression to the resonant frequency of a longitudinal mode of vibration.

These relationships stem from the basic equation:

$$f_r \propto \sqrt{\frac{Eg}{w}} \qquad (4)$$

where f_r = resonant frequency of the vibrational mode and harmonic employed
E = dynamic Young's modulus
g = acceleration due to gravity
and w = weight

The units of E, g, and w are arbitrary.

In recent years Kitazawa (10, 11), Bell and co-authors (2), and Hearmon (8) have shown that dynamic Young's modulus of wood specimens, as calculated from the data of either flexural or longitudinal vibrational tests, agrees closely with Young's modulus from static tests of a comparable nature. The methods employed by these investigators were primarily electrical-acoustical—techniques characterized by a high degree of accuracy. The tests were of a non-destructive nature since extremely low stresses were developed in the wood specimens during vibration.

Damping capacity measurements of solid wood have been chiefly of an exploratory nature with major emphasis on the variation between species. Such studies have been conducted by a number of workers (1, 3, 4, 7, 8, 12, 13, 14, 15). In the work conducted by these various investigators both "Q", sharpness of resonance, and logarithmic decrement (δ) were employed as measures of damping capacity.

Galginaitis and co-workers (5, 6) have shown in a series of reports that logarithmic decrement can be used as an indication of both solid wood and laminated wood quality. Although the feasibility of a test of this nature was indicated, the work of these authors cannot be considered entirely conclusive. Recent exploratory study (9) has shown that logarithmic decrement holds considerable promise as a measure of strength of solid wood and of the glue bond integrity of laminated wood.

[5] Other equally valid measures of damping are "Q", the sharpness of resonance, and the specific energy loss, $\frac{\Delta E}{E}$ where ΔE is the energy dissipated per cycle and E is the maximum energy of the cycle. It can be shown mathematically that $Q = \frac{\pi}{\delta}$, where δ is the logarithmic decrement.

[6] Dynamic Young's modulus is calculated from the data of a vibrational test while its counterpart, static Young's modulus, as implied, is calculated from the data of a static loading test.

[7] Poisson, Chaucy, and Savart (16) were some of the early investigators of elastic properties of materials by vibrational methods. Their work was conducted during the period from 1810 to 1840.

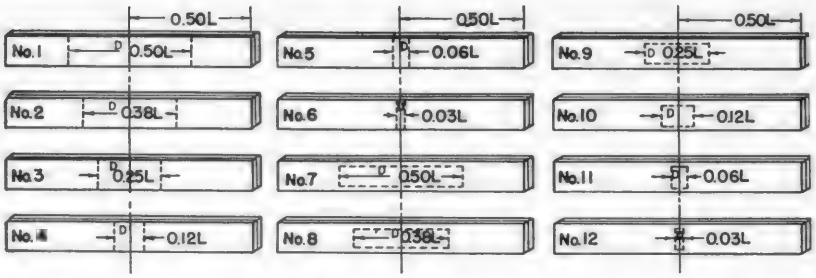

Fig. 2.—Location and size of defective glue line areas in a representative laminate of each group of specimens. D designates a defective area, and numbers indicate the length and position of defective areas where L = length.

Purpose of the Experiment

The present study was undertaken with the intention of more clearly ascertaining the practicability of a flexural vibration test as a measure of glue bond quality in wood laminates. The study was essentially designed to reveal the magnitude and type of glue line defect that could be resolved by a vibrational technique.

Material

Black Walnut *(Juglans nigra)* heartwood in the form of air-dry 4/4-in. flat-sawn boards was used for the study. This material was obtained from several sources located in the midwestern part of the United States. A total of 72 glued specimens, each consisting of two clear laminations was used. The 144 laminations for these specimens were machined from the original stock to dimensions of 0.45 x 2.20 x 30 in. Growth ring placement was parallel to the 2.20-in. face of each lamination and slope of grain in the direction of length was limited to 1 in 40. After selection the laminations were conditioned to a uniform moisture content of 10 per cent and machined to final dimensions of 0.25 x 2.20 x 26 in.

Following machining, and prior to assembly, each lamination was simply supported at two nodal points and resonated at its fundamental frequency. Both frequency and logarithmic decrement, as calculated from measurements of the frequency response curve, were recorded. On the basis of the logarithmic decrement, the test material was divided into 12 groups, each consisting of 12 laminae. The material in any one group was limited to laminations which exhibited logarithmic decrement within a range of ± 4 per cent of the mean for that particular group.

The laminations of each group were matched as six pairs, again on the basis of logarithmic decrement, with specific gravity as a supplementary means of matching. The matching scheme employed was designed to provide an individual group, later subjected to one treatment, with material of comparable damping characteristics. In addition, lamination matching in pairs within a group provided the final glued laminate with material of similar vibrational and density characteristics.

Two pairs of laminations, representing the extremes of logarithmic decrement within any one group, were resonated at successive resonant frequencies through the eighth harmonic and later assembled into the two nondefective control laminates of the group. The four remaining pairs of each group were assembled into four laminates containing various types of glue bond defects. The four types of defects were chosen to provide a range of glue bond quality in the defective laminates, as well as to simulate defects that commonly occur in laminated material. One laminate contained an area devoid of adhesive, the second contained an area covered with the wax of a common crayon but later spread with adhesive at the time of assembly, the third contained an area over which the adhesive spread had been allowed to exceed the maximum recommended assembly time, and the fourth contained an area over which the glue line was approximately 0.03-in. thick. The thick glue line area was developed by sanding an area on the gluing surface of each lamination to a depth of approximately 0.015 in. in order to develop a small indentation for the defective area.

Bonding was accomplished with Penacolite G-1260, a resorcinol-phenol adhesive. Glue line pressure was delivered to a group of ten stacked laminates by a series of five bar clamps spaced at regular intervals along the length of the specimens. Steel cauls two inches thick were used for gluing each individual defective specimen containing a thick glue line area. A curing temperature of 150° F. was maintained at the glue line for a period of six hours.

As outlined previously, four different types of defective laminates, as well as two well-bonded controls, were studied in each group. The extent and location of the various defect types were identical in the four defective specimens of each group. The location and magnitude of the defects in the 12 groups of specimens are illustrated in Fig. 2. Groups 1-6 (Lot 1) contained defective glue line areas which extended entirely across the laminate width. The defective areas in groups 7-12 (Lot 2), which were of the same length and location as the glue line defects in groups 1-6, were limited to the center ¾ of the laminate width. Thus these six groups of laminates

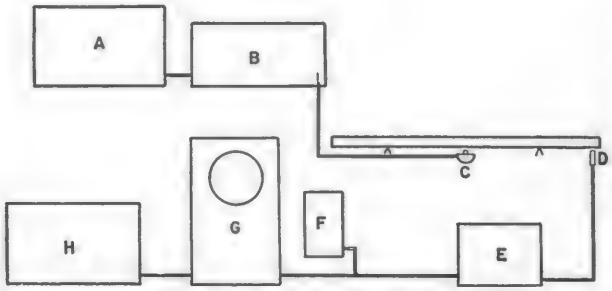

Fig. 3.—Test apparatus used to measure the vibrational properties of laminated specimens. (See text for meaning of symbols.)

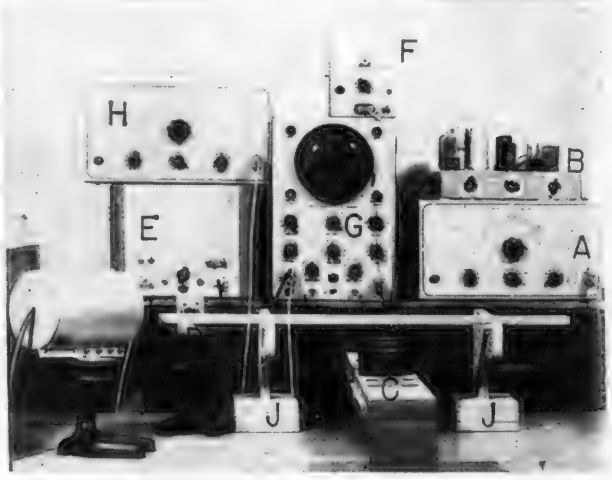

Fig. 4.—The complete test apparatus used for measuring the vibrational characteristics of laminated specimens. (See text for meaning of symbols.)

which were 2-in. wide had an included glue line defect 1½ in. wide which was bounded on each side by a glued edge of ¼ in.

Test Apparatus and Procedure

A previous study (9) of the vibrational characteristics of wood and wood laminates clearly showed that an electrical-acoustical apparatus for exciting, detecting, and measuring vibration provided highly accurate and reproducible data.

A schematic diagram of the instruments used for the vibrational testing of the wood laminates is shown in Fig. 3. The instruments are also pictured in the background of Fig. 4. For each test the specimen was suspended directly over a speaker-driver unit (C). Support was provided by fine silk threads positioned at two nodes corresponding to the harmonic frequency employed. The signal of an audio-frequency oscillator (A) was strengthened by means of an audio-amplifier (B) and applied to the speaker-driver (C).

The oscillation of the speaker diaphragm, which was controlled by the electric signal from the audio-oscillator, produced a vibrating mass of air between the speaker and the specimen. This air mass acted as a periodic exciting force which set the specimen in oscillation when its frequency was equal to one of the natural frequencies of the specimen. Each specimen was supported approximately ⅛ in. above the speaker throat with the supports (J, Fig. 4) positioned in such a manner that the exciting force was applied at an antinode.

Resonance, which is characterized by maximum amplitude of vibration with a constant driving force, was indicated by maximum output of the photo-electric tube (D). This resulted in maximum deflection of the voltmeter (F) and maximum amplitude of wave form on the oscilloscope (G). The output of the photo-electric tube was strengthened by means of a small battery-operated amplifier (E).

The transducing mechanism, consisting of the photo-electric tube and a focused light source operated on direct current[8], was ideal in the sense that no physical contact with the vibrating specimen was necessary for the conversion of vibrational movement to a measurable electrical quantity. Both the light source and the photo-electric tube were positioned at the upper edge of the vibrating specimen. During oscillation in the range of frequencies near resonance, the specimen cast a differential shadow on the photo-electric tube which produced a sinusoidal alternating current output at the tube terminals. After proper amplification, this signal could be viewed on the oscilloscope screen and measured by the voltmeter. As indicated previously this test method eliminated practically all sources of external damping which could seriously alter values of the vibrational properties. The damping effect of the supporting threads and surrounding air can be regarded as constant errors for all practical purposes.

The frequency at resonance was recorded and amplification in the system adjusted until full scale deflection of the voltmeter was obtained. The frequency of the driving audio-frequency oscillator (A. Fig. 3) was then reduced to a frequency corresponding to .707 of resonance amplitude (half-power point) and a signal from an additional audio-signal oscillator (H) was applied to the oscilloscope and adjusted to the same frequency. This was indicated by a stationary Lissajous figure[9] on the oscilloscope screen.

The driving audio-oscillator (A) was then swept through the resonant frequency of the specimen to .707 of resonance amplitude on the opposite side of the frequency response curve (Fig. 1B). This caused the Lissajous figure to migrate through a series of forms at a rate equal to the difference in frequency of equal amplitude points, in this case half-power points, on the frequency response curve. By timing the rate of migration with a stop watch, the width of the frequency response curve was determined. Logarithmic decrement was then calculated from a simplified form of equation 3.

The complete test apparatus is shown in Fig. 4. A special vibration-free work bench, shown in the foreground, consisted of a heavy laminated Douglas-fir top which was weakly coupled to a wood supporting frame by means of coil springs. The spring stiffness and mass of the top provided the system with a fundamental resonant frequency of approximately two cycles per second. The stiffness, dimensions, and mass of the top provided it with a fundamental resonant frequency of approximately 250 cycles per second—a frequency chosen to produce a minimum of interference with vibration of test specimens. Specimen supports, the photo-electric tube transducer, and the light sources were positioned on the bench top. The speaker-driver unit was supported above the bench top and rigidly coupled to the supporting frame in such a manner that its oscillation was not transmitted to the bench top.

The function of the bench was to isolate any external vibration, including oscillation of the speaker-driver, from the specimen supports and transducing mechanism. The relatively low frequency of the spring-mass system served efficiently in this respect. The electronic instruments used for measuring the vibrational characteristics of wood specimens are shown in the background of Fig. 4.

Each lamination and glued laminate was resonated three separate times at each harmonic frequency employed to ascertain the reproducibility of the measurements. As indicated previously, each lamination was resonated at its fundamental frequency and, in addition, laminations designated for future assembly into non-defective laminates were also resonated at their second to eighth harmonic frequencies. Each glued laminate, whether non-defective or defective, was resonated at its first five harmonic frequencies. Both frequency and logarithmic decrement were recorded at each harmonic employed. This range of harmonics entailed a frequency range of approximately 50 to 2800 cycles per second. The purpose of testing over this range was to observe the relationship between the logarithmic decrement and frequency both before and after gluing.

After completion of vibrational testing, each laminate was divided into a series of 23 shear blocks each with a shear area 2.00 in. across and 0.75 in. along the grain. A sampling procedure whereby the even-numbered specimens were tested to destruction was employed for the evaluation of each laminate. The purpose of this testing was: (1) to determine the quality and extent of the defective glue line areas, and (2) to evaluate the quality of the non-defective control laminates.

Results and Discussion

A typical relationship between logarithmic decrement and frequency of the control laminae of a single group both before and after assembly is shown in Fig. 5. Tests conducted on the laminae before assembly are indicated by eight single lines each with a cross-bar which represent the range and mean, respectively, at each harmonic frequency employed. Similarly, tests conducted on the same laminae after their assembly into two non-defective control laminates are indicated by five double lines each with a cross bar which again represent the range and mean, respectively, at each of the harmonics employed. Single lines represent 12 tests, three tests on each of four laminations, and double lines represent six tests, three tests on each of two laminates. In no case did the three tests conducted on a single speci-

[8] Direct current operation in contrast to 60-cycle alternating current operation prevented the transmission of light intensity fluctuations to the photo-electric tube.

[9] Richter, W. 1947. Fundamentals of industrial electronic circuits. p. 535. McGraw-Hill Book Co., New York.

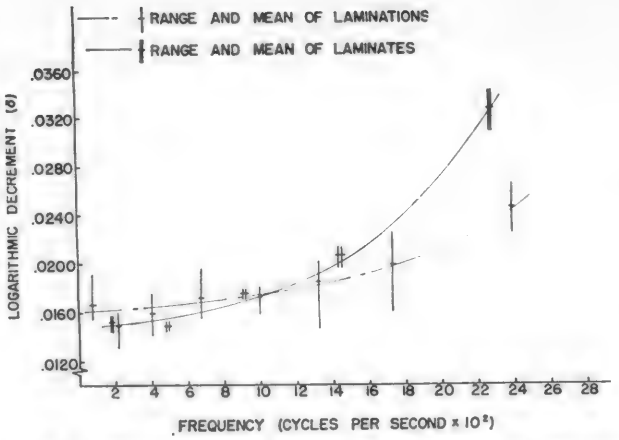

Fig. 5.—Relationship between logarithmic decrement and frequency for the laminae of a typical group. The material was tested over eight harmonics before gluing and five harmonics after gluing.

men (lamination or laminate) exceed ± 3 per cent of the mean of the three tests.

Although these data were not subjected to a rigorous statistical analysis, it is evident that the relationship of logarithmic decrement to frequency of the material both before and after gluing is curvilinear. In the lower two-thirds of the frequency range, the relationship between logarithmic decrement and frequency is essentially the same for the material both before and after gluing. In the upper third of the frequency range, however, logarithmic decrements of laminations and laminates showed a tendency toward divergence. The salient feature of the data shown in Fig. 5 is the significant reduction in variability of the logarithmic decrement of the material after gluing as compared to that before gluing. It was assumed that this reduction was brought about by an averaging effect through the bonding of two slightly dissimilar laminae.

Virtually every defective laminate exhibited an increase in the logarithmic decrement over that of its matched controls at one, two, three, or even four harmonic frequencies. This increase was most marked at the second harmonic frequency—a range of approximately 330 to 475 cycles per second. In addition, the resonant frequency of defective laminates exhibited slight decreases at the second harmonic as compared to their matched controls.

In order to critically evaluate these changes, both logarithmic decrement and resonant frequency as measured at the second harmonic were subjected to an analysis of variance. In the case of logarithmic decrement, the analysis showed that a highly significant difference existed between lot 1 (groups 1–6) and lot 2 (groups 7–12). Furthermore, the difference between control laminates proved to be non-significant, and the difference between control and defective laminates significant.[10] A comparable analysis using second harmonic resonant frequencies of the laminates proved to be relatively insensitive for the detection of defective material.

On this basis, regressions of logarithmic decrement (δ) on the length of glue line defect were plotted for the four types of defective laminates of each lot. The logarithmic decrement of the 12 control laminates of both lots of specimens was employed as the dependent variable and values of δ were plotted against the length of glue line defect associated with matched specimens of the same group. Since these laminates were defect-free and their laminae were originally selected on the basis of comparative vibrational characteristics, the trend of logarithmic decrement plotted against glue line defect length related only to variability in the control material. Theoretically this relationship should be parallel to the x-axis. Experimentally the relationship was linear but characterized by a slight negative slope. Due to the relatively small sample size (24 specimens), this was not considered unusual.

[10] Highly significant and significant differences between groups of data relate to probabilities of 99 and 95 percent, respectively, that these differences are not due to chance.

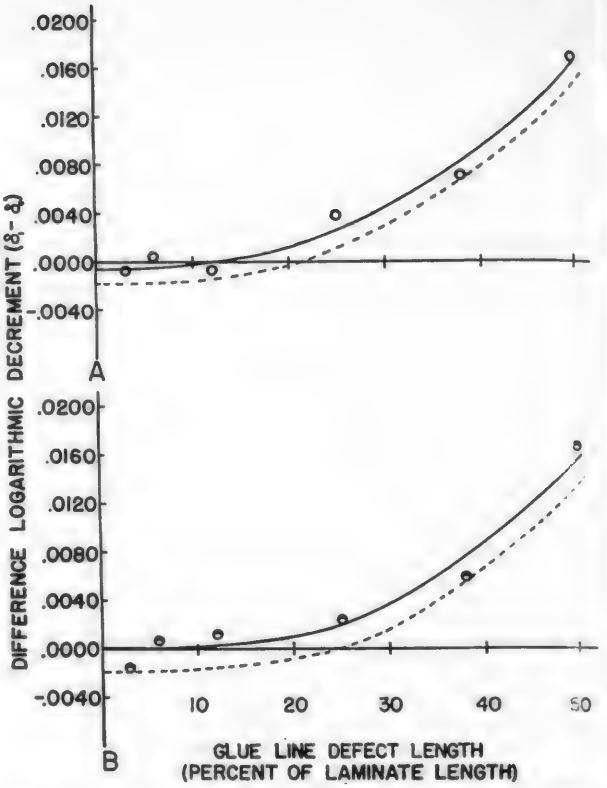

Fig. 6.—A (top): Relationship between the difference logarithmic decrement (δ_1-δ_0) and percentage of glue line length defective for the laminates of lot 1 with defects in the form of void areas. B (bottom): Relationship between the difference logarithmic decrement (δ_1-δ_0) and percentage of glue line length defective for the laminates of lot 1 with defects in the form of waxed areas.

The upper 95 per cent confidence limit of this regression was taken as the upper limit of variability of the non-defective laminates. Using this limit as a zero level, "difference logarithmic decrements" ($\delta_1 - \delta_0$)—where δ_1 = the logarithmic decrement of a defective laminate and δ_0 = the logarithmic decrement at the upper 95 per cent confidence limit of the control laminates—were plotted against the length of glue line defect of each type for both lots of specimens. In practical application the upper confidence limit of the variation about the mean value for logarithmic decrement of the species would be used as δ_0. However, due to the restricted sample size employed in this experiment, it seemed preferable to use the upper confidence limit of the regression of the control laminates as a zero level.

Relationships between difference logarithmic decrement and per cent of glue line length which was defective for the four types of defective specimens of lot 1 are shown in Figs. 6A, 6B, 7A, and 7B. In each case the broken line below each solid regression line is the lower 95 per cent confidence limit of the regression. The lower confidence limit shown in Fig. 6A (voids) intersects the x-axis at a glue line defect size of approximately 22 per cent

of laminate length. The intersection of the lower confidence limit in Fig. 6B occurs at approximately 25 per cent laminate length and intersection points of approximately 15 and 45 per cent of laminate length occur in Figs. 7A and B respectively.

The intersection points of these lower confidence limits with the x-axis indicate that at a probability level of 95 per cent, defects of the indicated type and size can be detected using this basis of comparison. Similar regressions of the defective laminates of lot 2 (defective specimens with edges bonded) all fell below the level of detection with the exception of the laminates containing glue line voids. The lower confidence limit of this particular regression intersected the level of detection at a glue line defect of 35 per cent laminate length. Obviously this type of test has limited applicability since in most uses the detection of much smaller defects than indicated here would be necessary.

It is pertinent to note that the "zero level", used as a basis for the comparison of material with defective glue lines, represents the upper limit of variability of the defect-free laminates at a probability level of 95 per cent. As has been stressed previously, the laminae of any one particular group were closely matched to each other with respect to the logarithmic decrement. Furthermore, it has been shown that the non-defective material after laminating exhibited approximately the average logarithmic decrement of the laminae prior to assembly in the lower two-thirds of the frequency range employed (see Fig. 5). Therefore, it should be possible to realize a more stringent segregation of material containing defective glue lines by the use of difference logarithmic decrement values based on individual matched controls.

Such a procedure was followed in the preparation of Fig. 8. The zero level of the data plotted in this figure

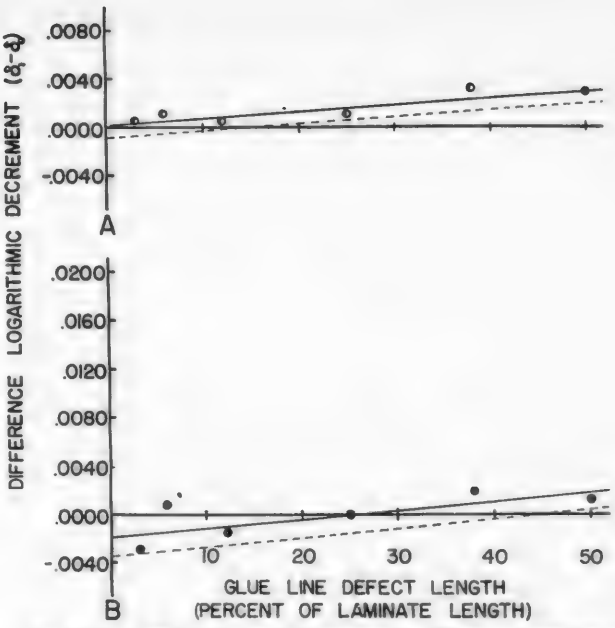

Fig. 7.—A (top): Relationship between the difference logarithmic decrement (δ_1-δ_o) and percentage of glue line length defective for the laminates of lot 1 with defects in the form of thick glue line areas. B (bottom): Relationship between the difference logarithmic decrement (δ_1-δ_o) and percentage of glue line length defective for the laminates of lot 1 with defects in the form of areas in which the maximum assembly time of the adhesive was exceeded.

is the maximum of the three individual tests conducted on the control laminate of each group which showed the higher range of logarithmic decrement. This value of each group was arbitrarily called δ_c. Logarithmic decrements of the defective laminates were called δ_1, and the difference logarithmic decrement taken as (δ_1 — δ_c). The free-hand curves of Fig. 8 show the trend of (δ_1 — δ_c) over glue line defect size as a percentage of laminate length for the four types of defective glue lines studied in lot 1. It should be emphasized that these curves are only trends and do not represent mathematical fits to the data.

The most important feature of Fig. 8 is that in only three cases (two of them questionable) did the difference logarithmic decrement fall below the zero axis. Similar trends in the relationship of difference logarithmic decrement to percentage of laminate glue line defective for specimens of lot 2 are shown in the curves of Figs. 9A and 9B. In these four relationships only five points fell below the zero axis.

Although some glue line defects were not detected by this type of comparison, in no instance did any one

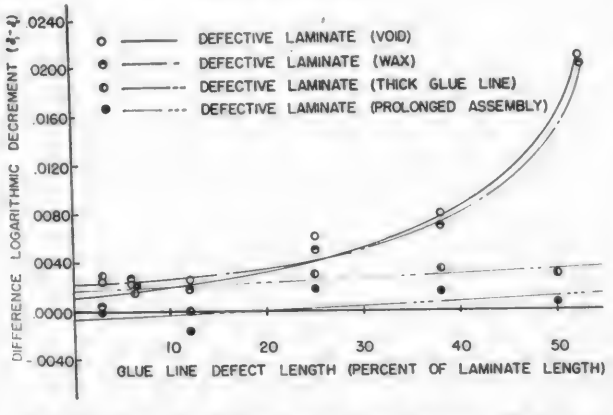

Fig. 8.—Trends of difference logarithmic decrement (δ_1-δ_c) over percentage of glue line length defective for four types of defective glue lines. (lot 1)

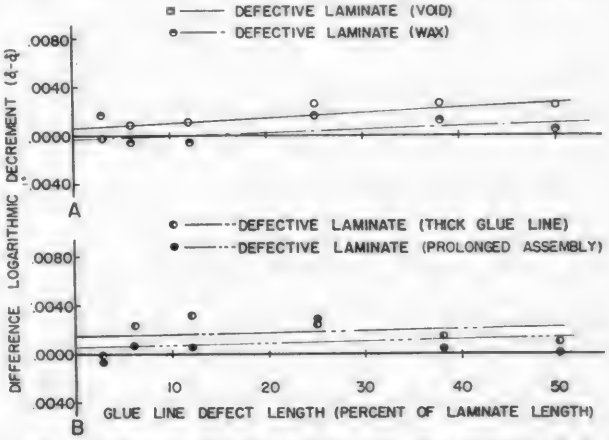

Fig. 9.—A (top): Trends of difference logarithmic decrement (δ_1-δ_c) over percentage of glue line length defective for the laminates of lot 2 which contained defects in the form of void and waxed areas. B (bottom): Trends of difference logarithmic decrement (δ_1-δ_c) over percentage of glue line length defective for the laminates of lot 2 which contained defects in the form of thick glue line areas and areas which had exceeded the maximum assembly time of the adhesive.

of these undetected defects exceed 12 per cent of the laminate length. Due to the ± 4 per cent range of logarithmic decrement within an individual group of laminae before gluing, and the selection of the extremes within any one group as control specimens, the logarithmic decrements of the laminae later employed for the fabrication of defective laminates fell below the value of the uppermost control. If the logarithmic decrements of each of these laminae had been known before assembly, then changes of the logarithmic decrement after gluing could have been attributed primarily to glue bond quality. It is possible that a procedure of this type could have resulted in the detection of virtually every defective glue line of the type tested regardless of size.

Destructive glue line shear tests of the 72 laminated specimens verified the presence of all defective glue line areas. No correlation of shear strength with non-destructive test data of the laminates proved of value. However, laminates containing glue line voids and waxed areas, which were characterized by maximum difference logarithmic decrement ($\delta_1 - \delta_c$) as shown in Fig. 8, were found to have zero shear strength in the defective glue line areas. Laminates which contained thick glue line areas and areas which had exceeded the maximum assembly time of the adhesive followed in successive order in difference logarithmic decrement. The defective areas of these laminates developed average shear strengths of 1272 and 1721 psi with ranges of 710–1823 and 326–2385 psi respectively. Non-defective control laminates developed an average shear strength of 3030 psi and exhibited a range of 2609 to 3320 psi.

Conclusions

The zero level of detection in the regressions shown in Figs. 6A, 6B, 7A, and 7B was taken as the upper limit of variability of the control laminates. Due to the relatively small sample size employed in this experiment, the upper 95 per cent confidence limit of the regression of difference logarithmic decrement on percentage of glue line length defective associated with matched specimens of the control laminates was used as the variability limit. This comparison permitted a thick glue line area as small as 15 per cent of the laminate length—only 3.6-in. long—to be detected (See Fig. 7A). The detection of defects in the form of void and waxed areas, and areas that had exceeded the maximum assembly time of the adhesive, was limited to sizes of 22, 25, and 45 per cent of the laminate length respectively. In practical application of this technique, the zero level of detection employed for segregation of defective laminates would, of necessity, be the upper limit of variability of logarithmic decrement about the average value of the species used for laminating. However, due to the relatively large amount of variability that is present in the vibrational characteristics of solid wood, this means of inspection does not hold a great deal of promise for the direct testing of laminated wood in its final form.

A more successful technique for the detection of defective laminates is that shown in Figs. 8, 9A, and 9B. By this method, comparison of the logarithmic decrement of defective laminates with matched non-defective controls provided a much more complete segregation of defective from non-defective material permitting defects of any type as small as 12 per cent of the laminate length—a defect only 2.9-in. long—to be consistently resolved.

An alternate procedure that holds even more promise for the detection of laminates containing faulty glue lines involves the testing of individual laminae before assembly and of the completed laminate following gluing. This scheme of testing would provide information on the vibrational characteristics of laminae before gluing which could be used for comparison with the final glued product. Increases of logarithmic decrement after gluing could then be attributed primarily to the quality of a glue bond.

Although not treated in this paper, there is a possibility that vibrational testing at higher harmonic frequencies would also be of value for the segregation of defective from non-defective laminates. Both of these possibilities will require further study in order to develop the full potentiality of the vibrational testing technique in a scheme of quality control.

Summary

A new method for the non-destructive evaluation of glue bond quality by means of vibrational testing has been described. The use of an electrical-acoustical system for exciting, detecting, and measuring vibration has made it possible to accurately measure the resonant characteristics of laminated material.

Four types of defective glue lines of varying extent as well as matched non-defective control laminates were studied. Results showed that all four types of glue line defects could be consistently detected down to a size of 12 per cent of the entire laminate length by comparison of defective laminates with individual matched non-defective controls. Furthermore, it is possible that smaller glue line defects could have been resolved had the vibrational characteristics of the individual laminae before assembly been known for comparison with the final glued member.

Acknowledgments

Mr. R. E. Pentoney, Instructor in Wood Technology, College of Forestry, State University of New York, designed the original transducing mechanism and amplifying circuit for converting vibrational movement to an electric signal. Appreciation is expressed to Mr. Pentoney for use of this design.

Gratitude is expressed to Frederick F. Wangaard, Professor of Forest Products, Yale School of Forestry, for his constructive criticism of the experiment and manuscript.

Literature Cited

1. Barducci, I., and Pasqualini, G. 1948. Misura dell' attrito interno e delle constanti elastiche dei legno. Istituto Nazionale Di Electroacustica. Centro Di Studio Consiglio Nazionale Delle Ricerche Presso L 'Universita Di Roma.
2. Bell, E. R., Peck, E. C., and Krueger, N. T. 1950. Young's modulus of wood determined by a dynamic method. U. S. Forest Products Lab. Report R1775.
3. Fukada, E. 1949. The vibrational properties of wood. Jour. of Phys. Soc. of Japan 5: 321–327.
4. ---------. 1950. Vibrational study of the wood used for the sounding boards of pianos. Nature 166 (4227): 772–773.
5. Galginaitis, S. V., Bell, E. R., Fine, A. M., Auer, G., and Roy, J. Reports for April 1, 1952 to June 30, 1953; July 1, 1953 to August 31, 1953; and Final Report. The non-destructive testing of wood laminates. Office of Naval Research, U. of Louisville, Inst. of Industrial Research.
6. --------- and Gazo, G. Report for September 28, 1953 to February 28, 1954. The non-destructive testing of wood laminates. Office of Naval Research, U. of Louisville, Inst. of Industrial Research.
7. Greenhill, W. L. 1942. The damping capacity of timber. Jour. Coun. Sci. and Res., Div. of For. Prod, Australia. 15 (2): 146–153.
8. Hearmon, R. F. S. 1948. The elasticity of wood and plywood. Forest Products Research Special Report No. 7. H. M. Stationary Office. London.
9. Jayne, B. A. 1954. A new non-destructive test for wood and laminated wood. Preprint, Fall Meeting, Northeast Section, FPRS.
10. Kitazawa, George. 1950. Non-destructive testing for forest products. Proc. FPRS 4:191–197.
11. ---------. 1952. Young's modulus of elasticity of small wood beams by dynamic measurements. Jour. FPRS 2 (5):228–231.
12. Krueger, F. and Rohloff, E. 1938. Ueber die innere reibung von holz. Z. Physik 110: 58–68.
13. Narayanamurti, D. and Prasad, D. N. 1949. The damping capacity of some Indian timbers. Jour. of Aeronautical Soc. of India 1 (3): 30–37.
14. --------- and Jain, N. C. 1951. The damping capacity of some Indian tim-

bers: II-logarithmic decrements in flexure. Jour. of Aeronautical Soc. of India 3 (3): 79–87.
15. Rohloff, E. 1940. Ueber die innere Reibung von Geigenholz. Z. Physik 115: 64–66.
16. Todhunter, I. and Pearson, K. 1886. A history of the theory of elasticity and of the strength of materials. Vol. I. Cambridge University Press.

Discussion

Harold Tombach (Consulting Engineer): What are the inadequacies of X-ray investigations of glue lines?

Mr. Jayne: We have found in our studies at Yale that only glue line voids could be detected by an X-ray technique. Since this type of defect occurs infrequently in commercially laminated material, its detection would not be of any great value. Although not studied by us, it is quite possible that thick glue lines could also be resolved by the X-ray method.

Mr. Tombach: How would one proceed to apply the vibration method to the investigation of actual glued-up products?

Mr. Jayne: In order to realize the full sensitivity of this test method, it would be necessary to study the resonant characteristics of the material of a laminate before gluing. This data would provide a basis for comparison with the final glued product. Changes of vibrational characteristics of the material after gluing could then be attributed to the glue lines.

Mr. Tombach: Is it always necessary to have a control? Also, how long does it take to perform a test?

Mr. Jayne: In a production scheme of testing, the vibrational characteristics of the laminate before their assembly would serve as the control for each laminate after gluing. In this sense it is necessary to have a control for each laminate in order to realize the full sensitivity of the test method. In answer to your second question, it requires approximately three minutes to perform each test.

A. D. Hofstrand (Oregon Forest Products Laboratory): Have multiple glue lines been studied by this method? How would such tests work?

Mr. Jayne: Our work has been confined to a study of laminates of simple design which contained only a single glue line. It seems possible that the method would work with multiple glue-line assemblies, although further research is necessary in order to ascertain this. I might add that we are planning to study multiple glue line assemblies in the near future.

Tom McKenna (Monsanto Chemical Co.): Do you think the method would be practical to test large laminated members?

Mr. Jayne: Recent studies conducted at the U. S. Forest Products Laboratory have shown it possible to resonate a member as large as a railroad tie. This work suggests the possibility of glue line testing on large assemblies.

John M. Yavorsky (State U. of N. Y., College of Forestry): Do you think it is possible to use a sonic method for testing furniture joints?

Mr. Jayne: I would not say it was impossible. However, due to the nature of the test, such an application would be very difficult to perform.

A New Method for Testing Wood Adhesives: I. The Specimen[1]

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A study was initiated to devise an easily conducted procedure for evaluating wood adhesives. This paper presents considerations involved in selecting a test specimen. The so-called cross-lap specimen was chosen because it appeared to possess sensitivity to adhesive and application variables, as well as controllability for observations of small differences among such variables. Advantages and disadvantages of the specimen are discussed.

Introduction

STRENGTH TESTS are one of the most important means of determining many different characteristics of adhesives, from chemical composition to their use in bonded structures. While adhesives may be represented by a number of measurable chemical and physical properties such as viscosity, pH, particle size, solids content, polarity, and rate of hardening, the ability to form a bond of prescribed strength is the ultimate test of a formulation. Bond-forming properties are normally checked by the use of standard test specimens.

Strength tests are also used to evaluate handling properties such as storage, pot and spreader life, assembly time, and pressure requirements. The durability of a bond is estimated by strength tests after subjecting specimens to appropriate exposure conditions. Finally, the performance of adhesives under actual use conditions involving different products, equipment, workmanship, and service exposures is often confirmed by using strength specimens cut from the product itself.

The purpose of these tests is, in the final analysis, to determine the suitability of a given adhesive for a certain application. Basically, this means obtaining data and interpreting it. Many problems are reducible to difficulties originating at these levels. The difficulties arise from innumerable factors, endlessly compounded, existing between the ingredients of an adhesive and the testing of a bond. Some of these factors are complex. They begin with the conditions under which the tree grew and end with the manner in which the specimen is held during loading. Thus, among the scores of factors which are known to affect bond quality and which are the object of study, there are also many factors which affect strength observations but about which little is known.

Further complications ensue because of both direct and interaction effects of nearly all factors that can be mentioned. Determining the suitability of an adhesive by means of strength tests therefore inevitably necessitates contending with two factors: (1) exces-

[1] First in a series of contributed papers based on a thesis submitted in partial fulfillment of requirements for the Ph.D. degree at the University of Michigan.

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sively large experiments incorporating a reasonable number of important known factors at various levels and combinations, and (2) many replications to overcome the overshadowing effect of the large variations caused by unknown and uncontrollable factors.

The first is brought on by the fact that bond-forming properties vary with the conditions of use. Adhesives vary widely in what may be considered optimum gluing conditions; i.e., a given set of conditions may permit one adhesive to form its strongest bond while another adhesive may find the same conditions unfavorable. For example, a casein adhesive does not form its strongest bond under the same set of conditions that a urea adhesive might form its best bond. Moreover, in normal production situations, conditions vary both knowingly and unknowingly. The evaluation of an adhesive should properly take into account a range of factors if it is to accurately represent how that adhesive will perform.

The second factor is a consequence of ignorance. There are still many voids in our knowledge of what influences a given strength observation. It is common, for example, to observe a wide variation between two specimens treated exactly alike and drawn from adjacent material. Hence, it is difficult in experiments to separate the effects of imposed treatments from the effects of chance operation of unknown factors. This can be done statistically if a measure of the chance variation can be obtained.

A measure of chance variation is secured through replications, that is, by repeating the experiment several times. This, however, results in inefficient experimentation. Statisticians have recently attacked this problem by devising self-replicating or partial replicating experimental designs. Converging on the problem from another direction, many researchers have investigated the area of the unknown and attempted to reduce the number of chance factors such as local differences in surface properties, and capricious variation of stress concentrations.

The work reported in this series of papers may be regarded as another approach to the general problem of obtaining adhesive data since it deals with a method of making observations in this field. Originally initiated to devise a test procedure which would be easy to conduct, the study led also to the development of low-cost, simple-to-construct equipment. The specimen used, the so-called cross-lap specimen, was thought to possess sensitivity to adhesive and application variables, as well as controllability for observations of small differences among such variables. A test method which would permit the use of a minimum number of specimens incorporating a maximum number of test variables, and which could be closely controlled for wood and processing variables, would appear to offer advantages for the observation of adhesive properties.

In the present paper, some background information is presented leading to the selection of the specimen. Subsequent papers will cover the construction of a machine for assembling and testing the specimens together with studies on the sensitivity of the specimen to controlled bonding factors. Experimental conditions studied included bonding factors such as assembly time, pressure, and age of the adhesive mixture; adhesive factors such as type, amount of extension, and rate of curing; wood factors such as thickness, specific gravity, and moisture content; and mechanical factors such as rate of loading, type of grip, manner of loading, and configuration of the bond area as altered by blocking agents in the glue line. Many of these factors were observed in combination and studied by analysis of variance techniques.

A major result of the work is a proposal of an "Intolerance Index" as a criterion for the suitability of wood adhesives. This index is based on the variation produced in test data as the result of the influence of designated bonding factors operating at several levels. It is calculated as the sum of the individual variances and the interaction variances extracted from the analysis of variance table after removal of chance variation. Hence the Intolerance Index is a reflection of how critical are certain factors to the performance of the adhesive, or conversely, how foolproof is the adhesive when used under conditions where bonding factors vary. In one limited comparison, two adhesives similar in composition and strength requirements according to specification, were found to differ fourfold by the Intolerance Index.

Selection of the Specimen

One of the perennial problems in evaluating the quality of adhesive bonds is interpreting some strength figure in terms of a particular property. The strength of a bond as usually measured is invariably compounded with size of specimen, type of wood, moisture content and density of wood, grain direction, stress concentration—and all these are limited by the comparatively low strength of wood itself. Observation of strength of bond above that of wood appears to be out of the question. It can be reasonably argued, however, that when a bond equals the cohesive strength of wood, the ultimate has been attained provided no subsequent deterioration of the bond ensues.

In considering any specimen which is intended to develop numerical values for the observation of some attribute of a material, assurance is needed that the same or statistically identical values will always result from a given set of conditions. Otherwise there will arise speculation as to whether an observation reveals, instead, unaccountable changes in material quality, in conditions, or in the processing of the specimen. Present day methods in common use for measuring adhesive properties leave much room for this type of speculation. The interpretation of data thus often becomes hazardous except for broad generalities.

Another desirable consideration in a specimen is that the observed strength bear some consistent and, if possible, numerical relationship to the stress conditions encountered by glued constructions in service.

A major question arising from data of adhesive strength specimens concerns the distribution of the loading stress over the bonded area at rupture. It is generally recognized that the load is seldom distributed uniformly over an entire bond area. Experience shows that where there is abrupt change in cross section, there will be concentration of stress. Stress concentration varies with the size and geometry of the specimen in addition to the elastic moduli of the adhesive and adherend. Hence different values are obtained for strength of bond with different specimen dimensions. It is in accord with good research practice to inquire into the influence of this factor upon observations of strength.

An examination of the two currently popular specimens, the block shear and the plywood shear, Figure 1, (a) and (c), ASTM Methods D905-49 and D906-49 (3), shows that in both cases loading forces tend to create stresses excessively in the wood during testing; whereas stresses are concentrated at the bond in many constructions undergoing service exposures. It would seem that a more realistic, and also a more conservative, bond strength observation could be made if the specimen used would concentrate stress as much as possible in the bond, at the same time keeping the stresses from vulnerable edges of the wood members. Thus, the ultimate load would be more indicative of the actual condition of the bond, and wood failure would not be as likely to occur at relatively low loads.

Many types of adhesive strength specimens have been proposed from

time to time. Currently, the American Society for Testing Materials has adopted, or is in the process of standardizing, means for measuring such strength properties as shear strength by block, plywood and lap type specimens, tensile strength, cleavage strength, flexural strength, fatigue strength, and impact strength.

Wood adhesives have traditionally been tested in shear and most of the knowledge on adhesive action has been accumulated with respect to this strength property. In selecting a specimen, it was reasoned that the most fruitful area for new knowledge would be in some other strength property. The growing belief that adhesive bonds are primarily stressed not in shear, but in tension, as the result of shrinking and swelling of the wood, provided the initial suggestion for an alternative stressing system. Debruyne (4) and Dietz, Grinsfelder and Reisser (5) have theorized, and more recently Blomquist (6) has demonstrated, the existence of tensile forces at edges of joints. The theory is advanced that at the edges of bonded areas where bond failures usually originate, the individual particles of glue are under tension even though shearing forces are in operation on both sides. The author (7) is in some sympathy with this view, having observed qualitatively the action of joints glued with a flexible adhesive. The adhesive film develops a stringy appearance across the bond which may be easily observed and which indicates the presence of tensile forces within the glue line itself.

Adhesive bonds are generally considered to be weaker in tension than they are in shear. It is appropriate to test a material in its weakest property rather than its strongest. In the case of wood adhesives, a further consideration is in order. Wood is stronger in shear along the grain than it is in tension across the grain. Greater forces thus come into play in a shear test of a side-grain-to-side-grain joint than in a tensile test. This is one reason for the use of the block shear specimen. Tensile tests of butt joints, that is, end-grain-to-end-grain, would of course, provide even greater stresses on the bond because tension along the grain is the strongest property of wood. Such test joints, however, are not feasible because wood glues do not function well on these surfaces and maximum bonding power cannot be achieved. Moreover, butt joints are not used in wood constructions where high strength is necessary.

From the standpoints of the active tensile forces at edges of joints and the fact that joints are normally weaker in tension than they are in shear, it would appear that a tensile test of adhesive bonds might be a most revealing source of information. Since side-grain-to-side-grain is the usual condition, a tensile force normal to the joint would have to be imposed through the weakest direction of the wood. Such a tensile specimen could not register very high values before being limited by the strength of the wood. The so-called button specimen, ASTM Method D-897-49 (3), cleavage specimens (a special type of tensile test) and adaptations of the wood tensile test perpendicular to the grain, Fig. 1 (b), (d), and (e), are all limited by the weakness of the wood in tension across the grain.

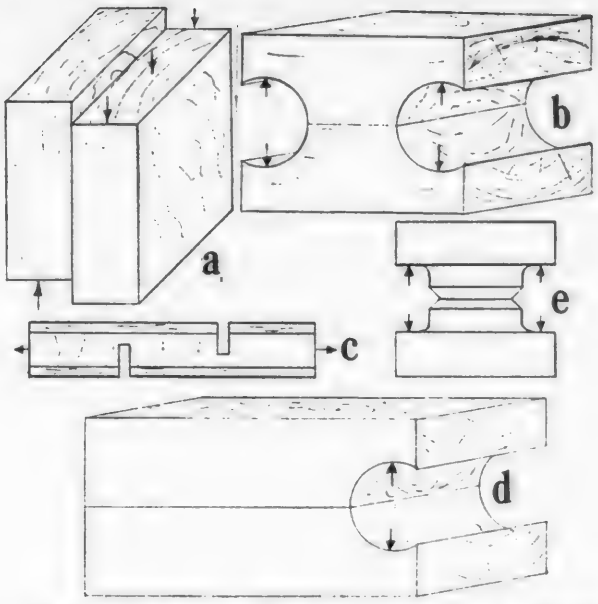

Fig. 1.—Wood adhesive test specimens: a) block shear specimen, b) tensile specimen, c) plywood shear specimen, d) cleavage specimen, and e) button specimen.

In spite of this contrary factor, it was felt that certain advantages resided in a tensile test by virtue of the direction of the forces involved, and that this warranted study to determine whether some means could be found to circumvent the limiting effect of low strength of the wood normal to the grain.

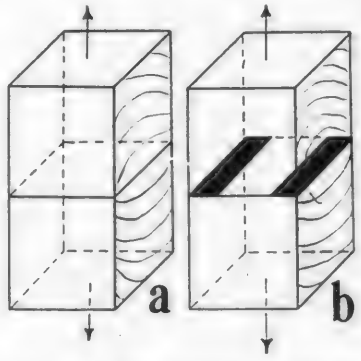

Fig. 2.—The cube specimen: a) joint area completely bonded; b) joint area half-bonded due to action of graphite film placed near end-grain portion of joint.

It was previously mentioned that stresses during loading are not evenly distributed over the bonded area of a specimen, and are likely to cause stress concentrations in the wood, depending upon the geometry of the specimen. This situation places the wood at a disadvantage with respect to the bond and is one cause of high wood failure and loss of significance. If the situation could be reversed to produce greater stress concentration in the bond than appears in the wood bearing the load, it might be expected that rupture would reflect the actual bond condition more accurately.

A start in this direction is made by the button specimen when used on wood, Fig. 1 (e). The cross section is necked down at the bond as shown. It may be observed that reducing the cross section in the vicinity of the bond does concentrate stress *at* the bond. However, this only assures that the break will occur at the center instead of at the shoulders if the bond is as strong, or stronger, than the wood. It does not alter appreciably the ratio of stress distribution between wood and glue because the wood adjacent to the bond approaches the same area as the bond itself. Yet, enough advantage is gained by the wood to reduce the amount of wood failure that would otherwise occur with a given test load.

A more positive way to alter the stress situation in favor of the wood is needed. One means of accomplishing this is shown in Fig. 2 where the bond area has been reduced with respect to the joint area transmitting

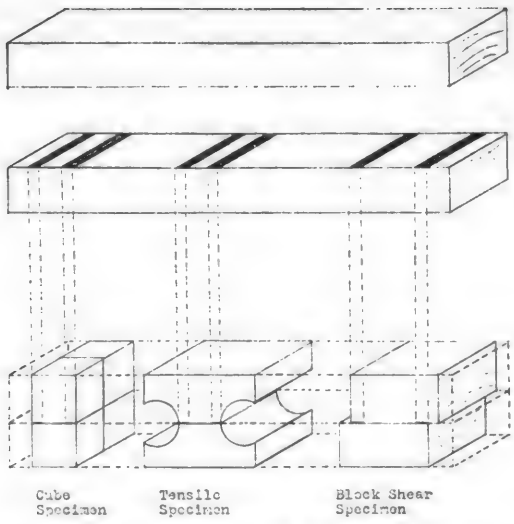

Fig. 3.—Method of applying blocking agent to certain portions of the joint to localize the bond area in adhesive specimens.

load to the bond. In (a), two cubes of wood one inch on an edge are glued together, side-grain to side-grain. If a tensile force is applied by gripping the end-grain sides of the blocks, the load per unit area is the same in the wood as in the bond. In (b), the same size specimen is made having the same joint area, except one-fourth of the bond area is prevented from forming (by a blocking technique later discussed) at each end-grain edge of the joint. Thus, there is twice as much joint area as bond area. This would lead at once to the assumption that the stress produced by the test load should be twice as great in the bond as in the wood.

Strictly speaking, however, the stress in the wood immediately adjacent to a bond must be equal to that in the bond itself. The difference in this specimen lies in the fact that the wood is continuous while the bond is discontinuous. A stress situation favorable to the wood should result since its continuity would permit some lateral dissipation of stress at the point where stress concentrations might be greatest in the bond. An additional advantage to the wood arises from the location of the bond with respect to the end-grain edge of the specimen. In being displaced inward, the bond can no longer carry stress to this free surface which is sensitive to tensile forces normal to the grain.

A number of preliminary experiments with this specimen, tested on a plywood testing machine with standard grips, gave values as high as 2000 pounds per square inch for the strength of a bond on hard maple without producing appreciable wood failure. Specimens could be made up in the same manner as block shear specimens, that is, using the same billets of wood, thus permitting close correlations between the two types of specimens. The procedure was to lay out the bond areas and the blocked areas on the face of one billet as in Fig. 3 and then glue in the normal manner, applying the adhesive to the face of the other billet. It was found that these areas could be relocated after the glued billets were jointed, so that the specimens could be sawed in the correct places.

Graphite applied with a soft lead pencil was the blocking medium used in the preliminary experiments. A thin film of graphite prevents adhesion and at the same time does not interfere with the normal flow movements of the adhesive since it does not occupy appreciable space in the joint. Other blocking systems were also used in later experiments, such as petrolatum jelly, silicone grease, wax crayon or liquid wax applied with a brush.

Fig. 4.—The cross-lap specimen.

This glue line blocking procedure is applicable to other specimens. It was tried on the standard wood tensile specimen normal to the grain (Fig. 1b). By judicious location of the blocked and unblocked areas, it was possible to drill the grip holes and cut out the specimen so that the bonded area occurred at the center of the joint area away from the end grain, (Fig. 3). G. Marra (2) used this procedure to investigate the sensitivity of standard glue specimens toward faults in the glue line. He found various plywood type shear specimens were remarkably insensitive to rather large unbonded areas.

While higher tensile strengths of the bond could be achieved with this blocking procedure, a number of disadvantages exist which appear to preclude its use as part of a simplified test method. (1) The introduction of a blocking agent into the procedure increases the possibility of surface contamination. (2) Variability of results are so great that deductions are not tenable except where wide differences exist. (3) The susceptibility to uncontrollable cleavage is high, making extremely sensitive self-aligning grips necessary. This was undoubtedly a contributing factor in the variability of results observed.

It was assumed that the two most desirable features of the graphite treated cube specimen just described were the concentration of stress at the bond, and the removal of the bond from the vicinity of end grain. The high ratio of joint to bond area is a desirability consequent to the manner of loading.

Advantages of Cross-Lap Specimen

Cursory analysis of the cross-lap specimen (Fig. 4) indicates that the desirable features mentioned above reside in this specimen also. No blocking agent is necessary. Since load is applied to the specimen through the bearing edges provided by the overhang, that is, the ends of the cross, the joint area may be considered as extending beyond the bond area.

In addition, other features of interest may be listed: (1) By suitable jigging, preparation of specimens may be done easily and in large numbers. (2) Specimens are glued individually in final form and thus require no machining after the glue hardens. (3) The wood blocks may be prepared in multiples from long strips and this promotes uniformity of machining large numbers of specimens. (4) Since specimens are glued individually, better randomization of wood variables should be possible. (5) Loads supplying bonding pressure and testing stresses are not large and the necessary

equipment need not be massive. (6) In producing joint surfaces in multiples while gluing singly, each specimen approaches more nearly a true fitting joint, and bonding pressure is not diverted uncontrollably to compressing high spots or overcoming warp. Thus, pressure should come under more positive control than is possible with other specimens glued in multiples. (7) Bearing edges for applying the test load are built into the specimen and these may be used either for compression or for tension loading. Other forms of loading such as torsion and impact are also visualized. (8) Since the grain of the wood is crossed, the maximum amount of shrinkage and swelling stresses may be imposed on the bond by moisture content changes. These are the most critical stresses a bond must withstand in service.

Disadvantages

Several disadvantages are also evident: (1) Since there is no machining after gluing, there is no trimming, and edge effects during bond formation therefore remain in the specimen. (2) Excessive squeeze-out of the adhesive may affect the observed bond strength either by forming a fillet at the juncture of the two wood members, or by destroying the flatness of the bearing surfaces. (3) There is a preponderance of end grain in the specimen and extreme care must be exercised to prevent moisture content changes during the course of an experiment unless this is one of the variables under observation. (4) The possibility of differential cleavage exists. (5) Bending of the specimen under load may influence the observed strength. This might impose difficulties in studying factors which affect both the wood and the bond, e.g., moisture content.

A cross-lap specimen has been in use for many years for testing glass adhesives (8). Its suitability for this purpose arises from the fact that grips which bite into the glass are not necessary. Recently a method using this specimen for testing glass adhesives was proposed to the American Society for Testing Materials. A cross-lap specimen is described by Kollman (9) as used by Rudeloff and also by several Forest Products Laboratory publications (10), (11). An experiment involving a cross-lap wood specimen is reported by Rudkin (12) of the Australian Forest Products Laboratory and by Pryor (13) of the Royal Aircraft Establishment. Recently, Foreste (14) attempted to compare results obtained with a cross-lap specimen with those obtained by the standard block shear specimen. His results were somewhat inconclusive due to wide variability in both methods. Hinken (15) has worked with a modification of a cross-lap specimen in which he used circular shims to study gap-filling properties of adhesives. In these investigations, no unanimity of dimensions appear to exist.

The dimensions of the specimen in the present research were established largely on arbitrary grounds, tempered by feasibility both in laboratory and process control work. It was thought that the bond area should be some even multiple of one square inch in order to facilitate computation. Since the area of the bond is determined by the width of the wood blocks, the width of the blocks should also be as close as possible to a whole number. One-square-inch area corresponding to one-inch wide blocks was considered too small an area for good functioning of the adhesive. A four-square-inch bond area corresponding to two-inch wide blocks was believed to be too large for easily generated testing loads. The decision, therefore, was between a two-square-inch area produced by 1.413-inch wide blocks, and a three-square-inch area produced by 1.731-inch wide blocks. The latter was considered most appropriate since a width of 1¾ inches could be specified without serious effect on the total area.

Thickness of the wood blocks remained as an experimental variable, although for the benefit of a standardized procedure this dimension was fixed at ¾ inches. The chief determinate here was that a thickness of ¾ inches could be obtained from most lumber that might exist where gluing operations are being conducted. Greater thickness would result in less bending under load and consequently less stress concentration. A feature of this specimen, however, is the possibility of diverting stress concentrations to the bond and cause the failure to occur there instead of in the wood.

The length of the wood blocks was a matter of convenience. There appeared to be no point in having the ends of the blocks extend farther beyond the edge of the bond area than was necessary to provide a good bearing surface. It was evident that if the test load could be applied as close as possible to the edge of the bond, it would minimize the effect of bending in the wood. A half-inch overlap was considered sufficient.

The final dimensions of the wood blocks making up the cross-lap specimen, which are regarded in this paper as the standard, are thickness—¾ inch, width—1¾ inches, and length—2¾ inches. These dimensions quite probably are not the most suitable from any single point of view but represent a certain amount of compromise and expediency. Certainly, different dimensions would result in different amounts of stress concentrations and hence in different strength observations. However, it was felt that this normally unfavorable factor could be turned to good advantage in promoting responsiveness to the effects of other gluing factors. If the specimen reflects the bond situation with a good degree of reliability, its usefulness may subsequently be established through further experience.

Bibliography

1. Staverman, A. J. 1951. Adhesion and adhesives. Chapter 2 edited by N. A. deBruyne and R. H. Houwink, Elsevier Publishing Co., New York.
2. Marra, George G. 1954. Investigation of test specimens for fundamental studies of adhesive behavior on wood. Presented at Northwest Scientific Assoc., Dec. 1954, Montana State U., Missoula; also Scientific Paper 504, West Va. Agric. Exp. Sta., Morgantown.
3. Anon. Sept. 1954. ASTM standards on adhesives. American Society for Testing Materials.
4. deBruyne, N. A. 1951. Adhesion and adhesives. Chapter 4 edited by N. A. deBruyne and R. H. Houwink. Elsevier Publishing Co., New York.
5. Dietz, A. G. H., Grinsfelder, H., and Reissner, E. 1946. Glue-line stresses in laminated wood. Trans. of ASME 68: 329.
6. Blomquist, R. F. 1954. Evaluation of glues and glued products. Jour. of FPRS IV (5): 290–299.
7. Marra, Alan A. 1951. Glue line doctor. Proc. FPRS.
8. Moser, Frank. 1948. Some fundamentals of glass adhesion. ASTM Bull. No. 150.
9. Kollman, F. 1936. Technologie des holzes. Berlin.
10. Truax, T. R. 1929. The gluing of wood. U. S. Forest Products Laboratory Bull. 1500.
11. Lewis, C. C., Heebink, T. B., and Cottingham, W. S. 1945. Effect of increased moisture content on the shear strength at glue lines of box beams and on the glue-shear and glue-tension strengths of small specimens. U. S. Forest Products Laboratory Bull. 1551.
12. Rudkin, A. W. 1947. A simple method of testing glue lines in tension. Jour. of Australian Coun. of Sci. and Ind. Research.
14. Pryor, M. G. M. 1942. Effect of dispersal conditions on joints made with casein glue. Royal Aircraft Establishment, Farnborough, England, Report Mat.-N-22051.
14. Foreste, David V. 1950. The development and evaluation of the crosslap test specimen and apparatus for testing adhesives in tension. Unpublished thesis, U. of Michigan.
15. Hinken, Edward W. 1953. A new method for observing the gap-filling properties of wood adhesives. Jour. of FPRS III (3): 15–20.
16. Anon. 1952. NAFM glue testing machine, construction and operation manual. National Assoc. of Furniture Manufacturers.
17. Reinhart, F. W. 1952. Survey of adhesion and types of bonds involved, symposium on adhesion. Case Institute of Technology.

18. Anon. 1951. Wood aircraft inspection and fabrication. U. S. Govt. Printing Office-ANC-19 Bulletin.
19. Pryor, M. G. M. 1944. Aging of urea-formaldehyde adhesives. Royal Aircraft Establishment, Tech. Note Mat-N-4-2051.
20. deBruyne, N. A. 1944. The strength of glued joints. Aircraft Engineer 16.
21. von Volkersen, Olaf. 1938. Die nietkraftverteilung in zugbeanspruchten nietverbindungen mit konstanton laschenguerschnitten. Luftfahrforchung 15:41.
22. Goland, M. and Reissner, E. 1944. The stresses in cemented joints, Jour. of App. Mechanics 66:A-17.
23. Koehn, George. 1952. Behavior of adhesives in strength testing, symposium on adhesion. Case Institute of Technology.
24. Maxwell, John W. 1944. Shear strength of glue joints as affected by wood surfaces and pressures. Tech. Pub. 64. N. Y. State Coll. of For., Syracuse.
25. Running, T. E. 1917. Emperical formulas. John Wiley & Sons Inc., N. Y.
26. Peakes, G. L. 1952. Fundamentals of a test method. ASTM Bulletin.
27. Wernimont, G. 1950. Precision and accuracy of test methods, symposium on application of statistics. ASTM, Special Tech. Pub. 103.
28. Marra, George G. 1949. A study of adhesive action of a urea-formaldehyde resin on certain hardwoods. Unpublished thesis, Duke U.

Survey of Factors Affecting Strength Tests of Glue Joints[1]

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Objectives of strength tests of glue joints are examined and factors affecting the results are discussed. The existence of stress concentrations in the conventional test specimens are demonstrated and recommendation is made that load at failure should form criterion of strength rather than stress calculated by dividing the load by the area of the section under test.

Introduction

CONSIDERABLE PROGRESS HAS BEEN MADE during the past three decades in the general art of fabricating wood with adhesives. However, little emphasis has been placed on the design and improvement of methods for evaluating the quality of wood-glue joints.

The knife or chisel test, the plywood tension shear test, and the maple glue block shear test have been used in the United States for commercial and research testing purposes. It has been readily accepted that these tests do not provide absolute measures of glue bond strength, but serve only as criteria for comparison purposes. Moreover, experience has also indicated that inherent sources of variability in these test methods often preclude valid conclusions even on a comparative basis.

In general, tests of glue bonds are made in an attempt to predict the behavior to be expected of the glued product in service. By considering the function a glued product must perform and the exposure conditions to which it will be subjected, some basis for acceptance or rejection is chosen. In most instances, the criterion established is that the test specimen must have a glued bond strength at least equal to that of the wood in the specimen. This line of reasoning leads to the use of the percentage of wood failure as the basis for evaluation of bond strength.

On the other hand, certain resin glues may show high bond strength in terms of the ultimate load at failure, but the failure will occur in the plane of the glue joint rather than in the wood. The question then arises as to whether the glue bond is acceptable or not. In addition, a strength value may or may not be suitable as a criterion in some cases, since the glued product should be considered as "failed" when it no longer functions properly in the light of its intended use, rather than basing failure on ultimate rupture of the joint. In other words, failure may be viewed as resulting from excessive deformation, delamination, loss in appearance, or a host of other factors quite unrelated to ultimate strength.

Furthermore, it is necessary to establish the goal of the testing program. Are "good" products to be separated from "bad" ones, as in a quality control inspection program in industry? Or, are such factors as species and moisture content of the wood, nature of the wood surface, type of glue, glue spread, assembly time, pot life, pressure, temperature and cure time to be evaluated on the basis of strength tests of glue joints as in applied research programs?

It is common experience to find that the strength of the glue joints in test specimens taken from adjacent areas in a test panel may vary by a factor of two to one. This extreme variability often results in a loss of confidence in the test, as well as preventing a realistic interpretation of the test results. For instance, in a quality control program a test with almost perfect discrimination, i.e., one which will not reject too many good items or accept too many poor items, is highly desirable. If the assumption is made that all low strength values are truly due to inferior glue joints, and not the result of the inherent variability of the test specimen, some items which really are not defective will be rejected. While this policy is conservative, it may also be expensive.

In a determination of the effects

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of gluing process variables, the inherent variability in test results may mask real effects since in any investigation there is little assurance that all of the pertinent variables have been completely randomized. In many cases some of the sources of variability or error tend to be systematic rather than random occurrences. These sources of error may reduce the sensitivity of the test severely, and often lead to confusing and unrealistic conclusions.

Sources of Variability

When a glue joint test specimen is loaded to failure, it is important to realize that failure may occur either in the wood, in the glue film, or at the wood-glue interface. Where failure will occur depends upon the magnitude and direction of the imposed stresses with reference to the weakest plane in one or more of these regions. Thus, the overall variability in test results reflects the inherent variability in the mechanical properties of the wood, the glue, and the wood-glue interface.

Wood, by nature, is variable in its physical make-up and behavior. In glue joint test specimens, the effects of variations in anatomy, specific gravity, moisture content, alignment of annual rings, and grain direction in the wood are factors of major importance.

In contrast, the glue is not quite as variable in its properties as the wood. However, the degree of cure or rigidity attained by the glue at the time of testing will determine whether the glue film is ductile or brittle, thus affecting the distribution of stresses imposed during loading. To further complicate the situation, the glue has a natural tendency to shrink while curing, and the restraint offered by the adjacent wood leads to development of residual stresses in the glue film.

The relative magnitude of these residual stresses and their effect on the results of strength tests have not yet been evaluated. However, it is known that thick glue lines may develop stresses great enough to cause rupture in the glue without the application of any external loading.

The strength properties of the wood-glue interface are influenced by both chemical and physical factors in the wood and the glue. These include the polar nature of the wood and the glue, their surface tensions at the interface, the presence of contaminants, the relative smoothness of the wood, wood anatomy and fiber alignment, and viscosity or mobility of the glue.

These sources of variability apply to *all* wood-glue joint test specimens. Other sources exist which are peculiar to a particular test specimen due to its geometry or method of loading. Sudden changes in cross-section and sharp, re-entrant corners, for example, create large stress concentrations.

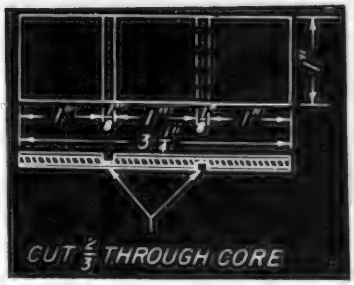

Fig. 1.—Dimensions of the standard plywood tension shear specimen.

Built-in bending moments due to eccentric loading and small changes in dimensions due to mis-machining of the test specimen often determine to a large extent the type of stresses imposed on the glue joint. It should not be surprising, then, that rather complicated stress configurations have been found to occur in the commonly used test specimens.

Standard Plywood Shear Specimen

The standard plywood tension shear specimen consists of three-ply plywood cut to the form and dimensions shown in Fig. 1. For standard test purposes, sweet or yellow birch veneer is used. However, upon agreement between purchaser and manufacturer of the adhesive, other species may be substituted in the test.

The specimen is fabricated with the grain of the face and back veneer parallel with the length. The center ply is crossbanded with the face and back. If the veneer thickness in the plywood specimen is 1/20 inch or less, the test area should be reduced from 1 to ½ square inch.

Three depths of cut are used in making the groove on the surface of each face, one of which must be specified in testing specifications:

1. Through the face ply only.
2. Through the face ply and also through two-thirds of the core ply.
3. Through the face ply and core but not beyond the second glue line.

Plywood test specimens are loaded in tension shear by exerting a pulling or extension force on each end of the specimen. Standard grips are used which clamp the specimen uniformly through a distance of 1 inch from each end. Testing is usually done in a universal testing machine or special plywood-testing machines such as the "shot" or fully automatic type. A uniform rate of loading of 600 to 1000 lbs. per minute is usually employed. The load to failure and percent of wood failure is obtained for each specimen.

Variation in Results

The results obtained in plywood shear tests vary considerably even on duplicate specimens of plywood. The causes of this variation were a subject of research at the U. S. Forest Products Laboratory (4)[2] and have also been covered in other publications (5,14). Some of the more important factors causing variation are as follows:

1. Factors related to the geometry of the test specimen and method of loading:
   a. Inherent eccentricity of the test specimen
   b. Depth of notch or groove
   c. Misalignment of the test grips
   d. Length of span between test grips
   e. Clamping pressure of the test grips
2. Factors related to the anatomy and physical properties of the wood:
   a. Slope of grain in the face veneers
   b. Orientation of lathe checks in the core veneer
   c. Specific gravity and moisture content of the veneers

[2] Numbers in parentheses refer to Literature Cited.

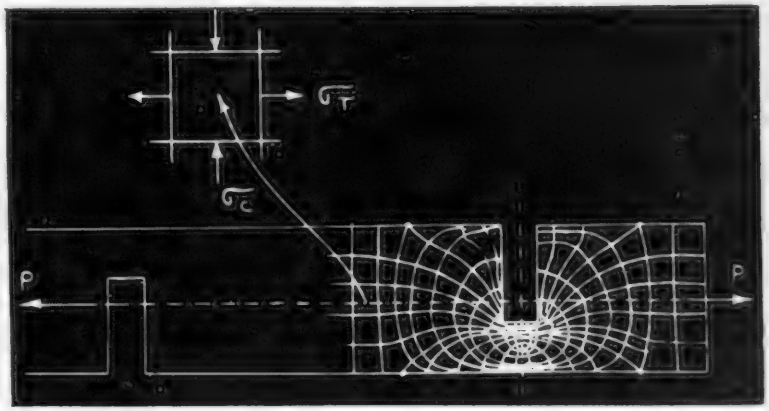

Fig. 2.—Stress distribution obtained photoelastically in an isotropic model of the plywood test specimen. (From Baud (3)). P = applied load, σ_c = direction of compressive stress, σ_T = direction of tensile stress.

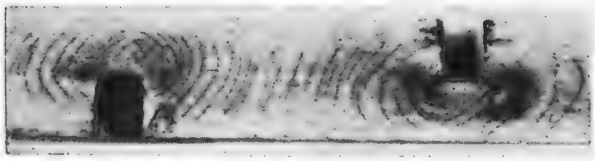

Fig. 3.—Strain pattern on a solid wood model of the plywood test specimen.

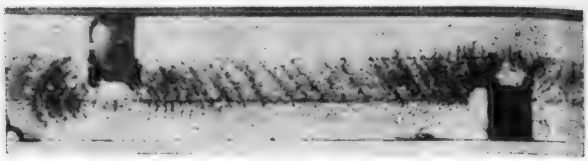

Fig. 4.—Strain pattern on the standard plywood tension shear specimen.

d. Elastic properties of the face and core veneers.

The salient feature common to these several sources of variability is that each affects the distribution and magnitude of the stresses imposed upon the glue-joint test section.

The stress distribution obtained photoelastically by Baud (3) employing an isotropic model of the plywood test specimen is given in Fig. 2. In the vicinity of the notch, "tearing" or tensile stresses exist normal to the plane of the glue-joint. Also, in this region, shear components occur in the plane of the glue joint. On the other hand, the main portion of the test-section is subjected only to tensile and compressive stress, i.e., the plane of the glue-joint is free of shear stress.

Although the use of a photoelastic model sheds some light on the stresses developed due to the geometry of the test specimen, its use is limited due to the fact that wood is an orthotropic material having three mutually perpendicular planes of elastic symmetry (11), the longitudinal (L), the tangential (T) and the radial (R) directions. Its elastic properties differ in these three directions; consequently, the stress or strain configuration cannot be rigorously determined by an isotropic model.

In an effort to overcome this difficulty, the application of a strain-indicating brittle lacquer (Stresscoat) to wood and wood-glue combinations has been investigated (18). The brittle lacquer has the property of cracking under tensile loading, and the location of the first cracks formed during the loading cycle indicates the region of maximum strain. The direction of the principal strain is perpendicular to a crack at any point in the crack pattern.

As an initial step, the Stresscoat was applied to a solid wood model of the plywood test specimen. The strain pattern, Fig. 3, indicated that in addition to the complicated configuration in the vicinity of the notches, the plane of the glue-joint test section was subjected to a component of shear along its entire length. Also, the existence of stress concentrations at the notches was indicated by the formation of cracks in these areas at low values of loading.

The advantages to be gained from the application of the brittle lacquer directly to the plywood test specimen are demonstrated in Fig. 4. The crack pattern provides a "picture" of the principal strains as they occurred in the actual specimen, rather than in an arbitrary model.

From Fig. 4, it is evident that a large component of shear existed in the plane of the core veneer of the three-ply specimen. The relatively low value of shear modulus for wood across the grain, in this instance, resulted in a rather large component of shear strain.

Any variation in shear modulus due to the anatomical features of wood and the existence of lathe checks in the core veneer will exert a pronounced effect on the amount of shear strain in this region. The presence of stress concentrations at the notches was again demonstrated by the formation of the initial cracks in these areas at low loads, whereas the central region was free of cracks until considerable load had been applied.

The curvilinear pattern of the cracks around the notches also indicates that high tensile or "tearing" strains occurred at varying angles to the grain of the face veneers. These tensile strains are due to the bending moments established by the eccentric loading in the specimen. Since wood is relatively weak in tension perpendicular to the grain, it is not surprising that failure may be initiated at the notches due to these tensile or "tearing" stresses. In addition, the flexibility of the outer veneers will control the amount of bending that occurs in the test specimen.

Goland and Reissner (9) have shown that theoretically the "tearing" stresses are reduced as bending occurs. In tests of hoop pine plywood made with various thicknesses of veneers, Higgens (10) found that higher breaking loads resulted in plywood made from the thinner veneers.

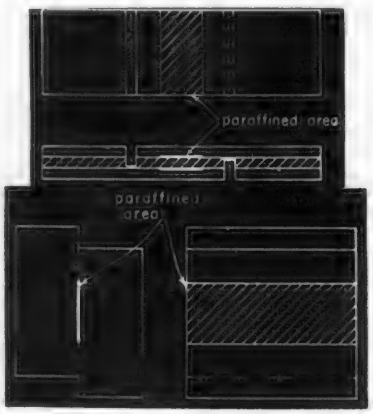

Fig. 5.—Standard test specimens with 50 per cent of the glue-joint blocked-off by paraffin.

In order to demonstrate the non-uniform nature of the shear loading which occurs along the length of the glue-joint test section between the notches in the test specimen, a series of tests were made with Douglas-fir and hard maple standard three-ply specimens in which 50 per cent of the glue-joint was blocked-off with paraffin to prevent adhesion. (See Fig. 5.) The assumption was made that if the shear stress was uniformly distributed, a corresponding reduction in strength of 50 per cent should occur.

100 plywood test specimens of each species were tested, half of the specimens having complete or 100 per cent bond areas, and half having only 50 per cent of the area bonded. The results shown in Table 1 indicate that the load at failure was reduced by an average of 17.1 per cent for the hard maple and 23.8 per cent for the Douglas-fir. Within either species, some of the reduced area specimens showed higher loads at failure than the control specimens.

While it appears possible that the plywood tension shear test might pass as acceptable some glue bonds which actually are 50 per cent defective, a "t-test" of the differences in breaking loads indicated that the specimens having 100 per cent bonds were significantly stronger than those having the reduced bond areas. Nevertheless, the results show that a non-uniform stress must exist over the glue bond area since the reduction in breaking load does not vary directly with the bond area.

A study of the mode of failure in the plywood test specimen was made employing a motion picture technique. The sequences of pictures in Fig. 6 shows the manner in which failure occurred in a 5-ply Douglas-fir test specimen.

Initially the test specimen appears straight in the grips, but application of the load caused bending to occur. The first failure was in cleavage (tearing stresses) near the notch. At this point the load dropped off markedly, but continuing strain produced a distinct cleavage-type failure.

In Fig. 7 a similar specimen shows failure in "rolling shear". This type of failure was demonstrated by Bethel and Huffman (5) to be significantly affected by orientation of the lathe checks in the core or cross-band veneers.

Maple Glue-Block Shear Specimen

The standard maple glue-block shear specimen, Fig. 8, was developed for the purpose of evaluating the adhesive strength of a glue, *per se*. The grain direction of the individual laminations should be parallel to the direction of loading both on the faces and sides of the test specimen. The end bearing-surfaces must be smooth and parallel to each other and perpendicular to the height of the specimen. In machining the end surfaces, care must be exercised so that the saw cuts extend to, but not beyond, the glue line.

Maple glue-block shear specimens are loaded in compression in a self-aligning fixture in an attempt to provide uniform lateral distribution of the load. Testing is usually accomplished in a universal testing machine which provides a continuous head motion of 0.015 inch per minute. The shear-stress at failure, based on the overlap area between the two laminations, and the percentage of wood failure is obtained for each specimen.

The causes of variability in test results are practically identical to those enumerated for the plywood tension shear test. Comprehensive analyses of the stress distribution in various types of compression shear specimens have been made by Coker and Coleman (7) and Baud (3). These analyses were based on photoelastic investigations employing isotropic models of the shear specimens.

The existence of high stress concentrations near the re-entrant corners, and the non-uniform shear stresses imposed over the test sections due to the geometry of the specimen and the method of loading were amply demonstrated. These investigators recognized that the stress distributions in wood specimens would differ from those obtained for the isotropic materials. An application of the Stresscoat technique has been made to this problem, and the results published in a previous paper (18) by two of the present authors.

A typical strain pattern is reproduced in Fig. 9. The formation of strain cracks in the vicinity of the notches at low loads indicated high stress concentrations in these regions, and the variations in the slope of the cracks along the test section indicated a variable shear stress over this area.

Recently, Radcliffe and Suddarth (15) reported on an investigation of the shear stress in the A.S.T.M. stand-

Table 1.—COMPARISON OF LOADS AT FAILURE FOR CONVENTIONAL AND REDUCED GLUE JOINT AREA PLYWOOD TEST SPECIMENS

Species of Wood	Test panel	No. of test specimens in group	Area of glue bond in sq. in.	Average load at failure in lbs.	Standard deviation of load at failure	Per cent decrease in load at failure	Average per cent decrease
Hard Maple	1	16	1.0	396	33.8	----	
		8	0.5	349	33.6	13.9	
	2	8	1.0	347	56.2	----	
		16	0.5	287	50.2	17.3	
	3	16	1.0	344	94.7	----	17.1
		8	0.5	261	46.1	24.2	
	4	8	1.0	461	60.6	----	
		16	0.5	401	63.1	13.0	
Douglas fir	1	16	1.0	235	25.3	----	
		8	0.5	175	16.0	25.5	
	2	8	1.0	299	36.4	----	
		16	0.5	232	20.2	22.4	23.8
	3	16	1.0	279	23.6	----	
		8	0.5	211	27.0	24.4	
	4	8	1.0	294	29.7	----	
		16	0.5	227	19.2	22.8	

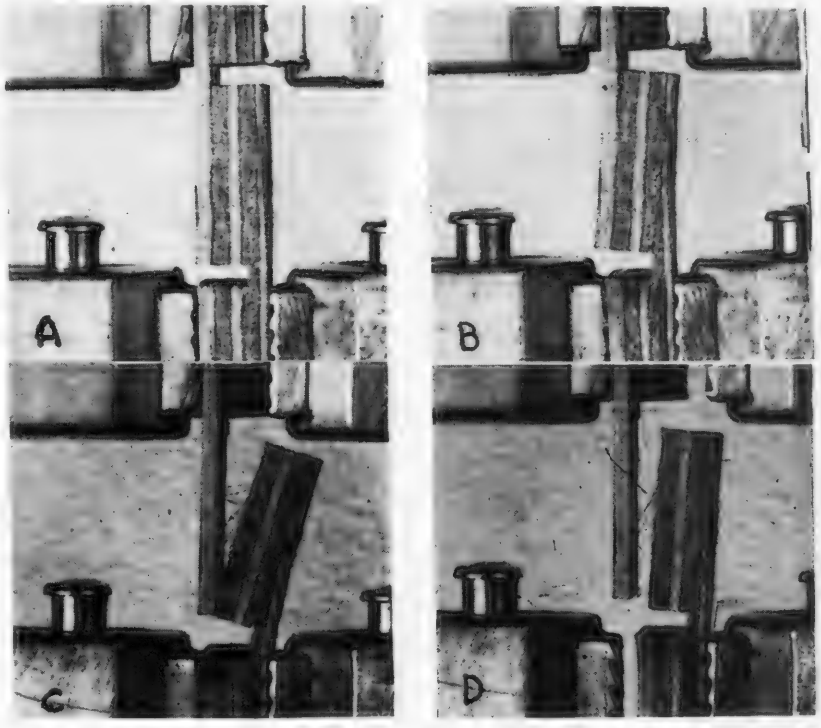

Fig. 6.—Sequence of failure in a 5-ply Douglas-fir test specimen. (A) Initial loading period. (B) Bending and initiation of cleavage-type failure at upper groove. (C) Extreme bending and continuation of cleavage-type failure due to "tearing" stresses. (D) Completion of failure sequence.

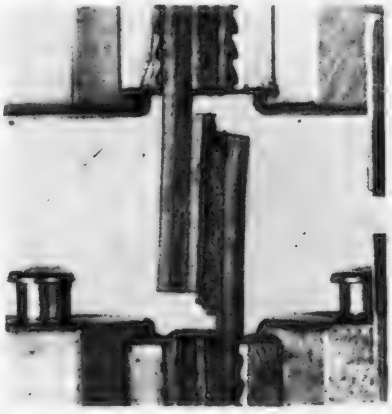

Fig. 7.—"Rolling-shear" type failure in 5-ply Douglas-fir test specimen.

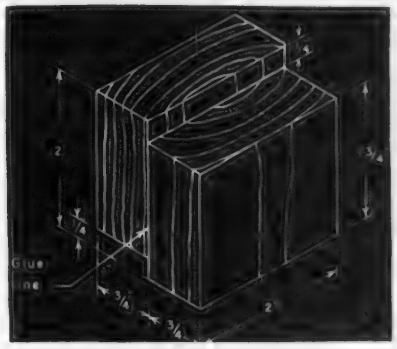

Fig. 8.—Dimensions of the standard maple glue-block shear specimen.

Table 2.—COMPARISON OF LOADS AT FAILURE FOR CONVENTIONAL AND REDUCED GLUE JOINT AREA MAPLE GLUE BLOCK SHEAR SPECIMENS

Test panel	No. of test specimens	Area of glue bond sq. in.	Average load at failure in lbs.	Standard deviation of load at failure	Per cent decrease of load at failure	Average per cent decrease
A	7	3.0	9336	2855	11.9	17.0
	6	1.5	8225	1399		
B	7	3.0	8717	2440	22.1	
	9	1.5	6789	2335		

ard wood shear specimen. In order to reduce the high stress concentration which occurred at the re-entrant corner in the test specimen, a slot terminated by a hole was cut perependicular to the grain at the re-entrant corner.

Although this modification was partially successful in reducing the undesirable stress concentration, they state ". . . This specimen is not recommended, however, since shear failures are often preceded by tension perpendicular to the grain failures". Based upon a stress analysis employing SR-4 electric resistance strain gages, they concluded that the behavior of the standard and the modified shear specimens did not permit valid interpretation of shear data and a notched beam shear specimen was recommended as a standard specimen.

Fig. 9.—Strain pattern on the maple glue-block shear specimen.

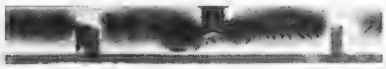

Fig. 10.—Strain pattern on French 3-ply plywood test specimen.

Fig. 11.—Strain pattern on German 5-ply plywood test specimen.

The reduced glue-bond area technique was also applied to the maple glue-block shear specimen (See Fig. 5). As shown in Table 2, the average load at failure was reduced by 17 per cent when the bond area was decreased one-half. Thus, it is evident that non-uniform loading occurs over the area of the test section.

In addition, the existence of tensile or "tearing" stresses perpendicular to the plane of the glue joint have been shown to exist, both by the photoelastic studies and the Stresscoat analysis. These normal stresses may result in failure of the specimen due to cleavage rather than shear.

Other Test Specimens

Three modifications of shear test specimens were used by McLeod and others (13) to determine shear strength by compression loading. The test specimens were all prepared by fabricating 3-ply test pieces between longitudinally grained outer bearing blocks. The center ply was oriented at various grain directions. Test specimens were termed as follows:

1. Modified ASTM Standard Shear Test of Wood.
2. Specimen for Double Shear Test.
3. Modified Block Shear Glue Joint Test.

In comparing shear-test results from these three types of test and also from plywood tension shear tests, a wide variation was found to exist between the shearing strengths as determined by each. No definite relation was found to exist between the four test methods, and such variables as species of wood and method of cutting differed in their individual effects on the results obtained by each test method.

Various types of adhesive test specimens are specified in MMM-A-175 (1) and Marra (12) has investigated the applicability of a cross-lap test specimen for the evaluation of glues. De Bruyne (8), Bock (6), Wakefield (17), Rinker and Kline (16), Northcott (14) and others have investigated the sources of variability in test results for a number of different adhesive test specimens employed in several foreign countries. The British plywood specimen (2) is similar to the American type except that it measures 5¾ to 6 inches in length.

In the present investigation, the strain distributions in the French and German plywood shear test specimens were obtained by the Stresscoat technique. From the strain configurations shown in Figs. 10 and 11, it is evident that these specimens offer no apparent advantage over the English or American types. Eccentric loading is inherent in all four, and stress concentrations exist due to the presence of stress-risers whether they are notches, grooves or holes.

Conclusions

Of the many types of test specimens employed by various investigators to determine the strength properties of adhesives, only the plywood tension shear test, the maple glue-block shear test, and the knife or chisel test have been widely accepted in the United States for commercial or research testing purposes.

Recent studies, including the present survey, have indicated some of the sources of variability influencing the results of these tests. Because of these limitations, there is an increased need for improved test methods.

The conclusions to be drawn from this survey of adhesive test specimens may be listed as follows:

1. Stress concentrations are inherent in the conventional test specimens due to the geometry of the specimens and the methods of loading employed.
2. The ability of a specimen to reproducibly reflect the actual condition of the glue bond over the section under test may depend more upon the stress distribution peculiar to the specimen than upon the variables under investigation.
3. Failure may be initiated in the conventional test specimens by stresses other than those nominally considered under evaluation.
4. Due to the non-uniform stress distributions which occur in the conventional test specimens, the load at failure rather than the stress (obtained by dividing the load by the area of the section under test) should be employed as the criterion of strength of the glue joint.

Literature Cited

1. Anonymous. 1951. Adhesives; methods of testing. Federal Specification MMM-A-175. General Services Administration, Washington.
2. Anonymous. 1954. Synthetic resin adhesives for plywood. British Standard 1203:1954. British Standards Institution, London.

3. Baud, R. V. 1954. In -Die Melocol—Leime der CIBA Aktiengesellschaft. Bericht No. 152. Zurich.
4. Bensen, D. W. and R. J. Preston. 1946. Some causes of variability in the results of plywood shear tests. U.S.F.P.L. Report No. 1615.
5. Bethel, J. S. and J. B. Huffman. 1952. Influence of lathe check orientation on plywood shear test results. School of Forestry, North Carolina State College, Tech. Report No. 1.
6. Bock, E. 1951. Prufung von Holzleimen. Holz als Roh-und Werkstoff, Vol. 9, No. 2.
7. Coker, E. G. and G. P. Coleman. 1935. Photoelastic investigations of shear tests of timber. Selected Eng. Papers No. 174, Institution of Civil Engineers, London.
8. De Bruyne, N. A. 1944. The strength of glued joints. Aircraft Engineering, April.
9. Goland, M. and E. Reissner. 1944. The stresses in cemented joints. J. App. Mech., March.
10. Higgens, H. G. 1946. Unpublished report—The effect of the dimensions of the test specimen upon the apparent strength of plywood. C.S. I.R.O. Australia.
11. March, H. W. 1944. Stress-strain relations in wood and plywood considered as orthotropic materials. U. S. F. P. L. Report No. R–1503.
12. Marra, A. A. 1954. An analysis of a wood adhesive test method using a cross-lap specimen. Ph.D. Thesis, University of Michigan.
13. McLeod, A. M., Yolton, L. A., Sauborn, W. A. and R. S. Phillips. 1945. A comparison of shearing strengths of glued joints at various grain directions as determined by four methods of test. U.S.F.P.L. Report No. 1522.
14. Northcott, P. L. 1952. The development of the glueline-cleavage test. Jour. F.P.R.S. II (5):216–224.
15. Radcliffe, B. M. and S. K. Suddarth. 1955. The notched beam shear test for wood. For. Prod. Jour. V(2):131–135.
16. Rinker, R. D. and G. M. Kline. 1945. Survey of adhesives and adhesion. N. A. C. A. Tech. Note 989.
17. Wakefield, W. E. 1947. The tension normal to glue line plywood test. Canadian F.P.L. Mimeo. No. 121.
18. Yavorsky, J. M. and J. H. Cunningham. 1955. Strain distribution in maple glue block shear specimen as indicated by a brittle lacquer. For. Prod. Jour. V(1):80–84.

Discussion

John Reno (Pacific Lumber Co.): What would happen if on plywood tension tests instead of having square cornered saw kerfs you had machine cuts with round corners? Would this be a better reflection of true psi?

Mr. Yavorsky: We tried this in plywood tension shear specimens but it didn't help at all. Characteristic strain patterns appeared the same. In machining the test sample, any small defects, especially in the notches, will set up planes of failure.

W. Shilling (Crown Zellerbach Corp.): Since rupture forces are the greatest along the top and bottom edges of the glue line under test, why not express the results of the test in terms of pounds per lineal inch instead of per square inch?

Mr. Yavorsky: This is all right if extended to the total periphery of area. Alan Marra, University of Michigan, found that the plot of bond strength against length of periphery of the failure area resulted in a straight line. Presumably once the periphery fails, the specimen fails.

H. Dan Stillwell (Oregon Forest Products Laboratory): What emphasis do you put on amount of wood failure which is indicative of poor bonds or good bonds?

Mr. Yavorsky: We think that much depends upon the condition of the wood involved. Once failure is initiated, planes of failure will follow the wood. High wood failure and high strength are ideally what we are looking for.

Harold Tombach (Consulting Engineer): Have you considered using torsion test specimens to determine the true shear strength of glued joints?

Mr. Yavorsky: In order to establish a true shear stress specimen, that is the only way you can do it. Adequate torsion specimens are extremely difficult to machine. The Elmendorf lab has developed a torsion test for plywood. Also, Block in Germany has worked on this technique.

P. L. Northcott (Forest Products Laboratories of Canada): Have you tried using a cleavage specimen?

Mr. Yavorsky: Cleavage in plywood and hardboard can be tested as in lumber. Specimens are made by drilling holes at one end of the specimens, then cutting away part of the hole and inserting tensile test grips in the hole. Such tests result in a concentration of high tensile stress at right angles to the glue line at the intersection of the glue line and the edge of the hole. Strain gauge techniques have been used to study these stresses. We don't yet have the complete picture on plywood and maple laminated specimens.

F. W. Herrick, Rayonier Inc.): You objected to the psi expression for bond strength. What about the effect of rate of loading on observed strength values?

Mr. Yavorsky: Our experience substantiates what the Forest Products Laboratory has found. We know that some tests use an impact or rapid break method, some the old-fashioned slower speed, and you can't compare results between extremes. The range of speed used generally is between 400–1000 pounds per minute.

Logging Small Hardwoods[1]

LELAND W. HOOKER

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Study was aimed at development of economical methods for harvesting thinnings in young-growth hardwood stands. Cost-raising factors of small size of timber and light cut were overcome with a new technique in hardwood silviculture. Removing thinnings in narrow strips resulted in significant reduction in logging costs.

EARLY THINNINGS IN HARDWOODS are fully as desirable as they are in conifers from a silvicultural standpoint. More such operations are not being carried out due to a combination of economic and technological factors.

The presence of markets for the products of early thinnings in softwoods spurred the development of silvicultural techniques, and the relatively rapid growth in response to thinning permitted the removal of volumes which could be handled economically with existing equipment. Until recently, however, markets for the wood produced in hardwood thinning operations have been extremely limited, and the nature of young hardwood stands is such that conventional logging techniques cannot always be applied economically.

This is a report on an experiment aimed at the development of economical means for harvesting thinnings from young second-growth hardwood stands. The experiment was subsidized by the Cliffs–Dow Chemical Co. of Marquette, Mich., in the interest of developing a future source of raw material for its wood-distillation plant. The Copper Range Mining Co. cooperated in the study by making available 80 acres of a typical young hardwood stand for the experimental logging.

As used in this report, the term "young hardwood stand" means an even-aged stand of dense hardwoods of mixed sprout and seedling origin in which the range of diameters is from 3 to 10 inches, with the average approximately 6 inches. In the Lake States, such a condition is normally reached 30 to 50 years after clear-cutting, at which time the volume may be from 25 to 35 cords per acre, and the stand is beginning to stagnate.

There will be approximately 650 stems per acre with a basal area of 110 to 115 square feet.

There are thousands of acres of such stands in the Lake States, with the principal species being hard maple *(Acer saccharum)*, beech *(Fagus grandifolia)*, soft maple *(Acer rubrum)*, yellow birch *(Betula alleghe-niensis)*, and basswood *(Tilia glabra)*.

Objective

Reduction of the cost of harvesting thinnings to the point where they could be sold for chemical wood at current prices was the objective of this study. At present the wood chemical plants are getting some thinnings from young hardwood stands, produced usually by farmers using family labor upon which no Workmen's Compensation Insurance is carried, and farm machines which are not charged to the logging operation.

The purpose of this study was the development of means whereby a jobber could equip himself for making a business of harvesting thinnings from young hardwood stands.

Scope

It was recognized that the key to economical harvesting would be in the bunching and skidding portions of the operation, so emphasis was placed on the movement of the harvested material to woods landings.

There was, of course, vital interest in the cost of various phases of the operation, but since costs for the same item will vary from region to region, the results of the study are expressed in units of production per man-hour and machine-hour. Any operator can then apply his own charges for labor, depreciation, overhead, insurance, taxes, etc., and arrive at cost figures applicable to his locality.

The Problem

The use of the crawler tractor for skidding, trucks for hauling, and the application of the internal combustion engine to other phases of timber harvesting have done much to reduce the diameter of and increase the distance to the marginal tree. They have made it possible to employ economically more desirable silvicultural techniques, such as selective cutting and more frequent thinnings.

Mechanization of logging alone has not accomplished these ends, however. Suitable markets for the smaller trees have had to be developed as well. Both from the standpoint of mechanization and suitable markets, however, thinnings from young hardwood stands have been generally beyond the limits of economic accessibility.

It is well known that with any given method the cost of logging varies inversely with the size of the trees being handled. Unfortunately, the curve of logging cost rises even more sharply when the volume removed per acre decreases. In addition, the nature of young hardwood stands is such that the desired density of the residual stand creates even more cost-producing problems.

The first factors considered were small size and low value, actually two aspects of the same problem. The product had to be delivered to the railroad car in the form of 8-foot sticks. Many of these are small enough to be man-handled, but some are too heavy for even two men to handle and must be handled by power. In either event, the value of the piece does not justify the cost of handling. For example, an operator can afford to spend quite a bit to handle an 8-foot veneer bolt worth $10, but there is little margin available for the handling of an 8-foot chemical wood stick worth 19 cents f.o.b. the railroad car ten miles from where it grew.

Compounding the effect of small size and low value is the factor of light, scattered cut. Seldom is it possible for a tractor to pick up a full load at any one spot, which means that the ratio of non-effective time to effective time is increased. Once again, an operator can afford more non-effective machine

[1] Presented at Session III, Logging and Milling, FPRS North National Meeting, June 21-24, 1955, in Seattle, Wash. Read by A. W. Toole, Lake States Forest Experiment Station.

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Fig. 1.—Loading bundles with a self-loading truck—Phase I.

Fig. 2.—Skidding tractor with swing-boom and racking-bunk dray—Phase II.

time and travel greater distances to pick up that $10 peeler log than you can to bring in the 19-cent chemical wood stick.

The result of a light, scattered cut, of course, is a relatively dense residual stand. For example, the removal of eight cords per acre in one young hardwood stand reduced the basal area to 85 square feet, distributed over 550 stems. Such a stand definitely impedes the movement of mechanical equipment, especially when it is considered that the stumps of the 100 to 125 trees which were removed are still there to get in the way.

In practice, the density of the residual stand dictates that the skidding equipment stay on prepared trails nearly all the time. Further, it makes it impossible to fell the trees in the desired direction in most instances.

The Attack

Since manpower costs more than horsepower, the objective of mechanization must be to reduce the number of man-hours required to produce a given unit of wood. To do this requires not only that the proper machinery be selected, but that it be applied in the most advantageous manner.

The selection or design of equipment can often be made on the basis of past experience, but any application involving modification of existing techniques must be worked out in the field. A field experiment involving cutting on 80 acres of young hardwoods was laid out, and operations were carried out which approximated as closely as possible, considering the experimental nature of the work, commercial harvesting operations.

Since the end product of the operation was to be low in value, it was decided to try to work out a system which would require the lowest possible initial investment in equipment. With this objective, the tractor selected was an Oliver OC–3 crawler equipped with a Carco winch and a Trailbuilder blade.

Phase I—1952: At first thought, it would seem that little could be done about the factor of economical size of timber. It was felt, however, that actually the size factor offered the best opening for the initial attack on the problem. In brief, it was reasoned that if the individual sticks were too small to be handled economically, they could be gathered together and bound in a bundle which could be handled economically.

The influence of the light cut would be felt in the gathering together of the sticks, but it was believed that individual handling could be eliminated early enough in the harvesting process to give the desired results. Bundles should, of course, remain intact at least until the wood was placed on the railroad car.

In view of the proved economies of tree-length skidding in the harvesting of sawlogs, it was decided to try the method in the harvesting of 40 acres of second-growth hardwood thinnings, using a Carco Jr. rubber-tired sulky. It was felt that in this way the skidding tractor would not have to maneuver through the residual stand, but could remain on prepared skid trails, reaching out with the winch cable to where the trees lay after felling.

Further, the use of snatch-block chokers would permit the gathering together of an economical load in a minimum of time. Bucking would be done at the woods landing, where ⅔ to ¾-cord piles would be made. These piles, after chaining with two Grip-Trip bundling chains, would then be loaded, transported, and unloaded as bundles.

All of the felling was done in advance of the skidding in order to insure that the skidding crew would never be held up for lack of logs. The skidding crew consisted of a tractor driver and a choker setter, and two men bucked and piled on the landing. There were times when the skidding crew had to help the buckers in order to clear the landing.

A self-loading truck designed for log handling was used for the hauling, but considerable difficulty was experienced in lifting the bundles onto the truck. The truck unloaded itself at the railroad, and here again trouble sometimes developed when the bundles were swung over onto the gondola car, because the weight of the bundles imposed too great a strain on the frame of the truck.

This operation failed to give economical production per man-hour chiefly because of the density of the residual stand. In order for tree-length skidding to be practiced economically, felling of the timber needs to be done with considerable precision, creating a herringbone pattern with respect to the skid trails.

Because the residual stand was so dense, it was extremely difficult to get the trees to fall in the proper direction. In fact, it was difficult to get them to fall at all. The result was a badly jack-strawed tangle of trees, and the time consumed in getting them to the skid trail did not permit the desired high production per man-hour. Only .12 cords were produced per man-hour (8.1 man-hours per cord), and .60 cords per machine-hour (1.7 machine-hours per cord).

Fig. 3.—A 15-foot clear-cut strip showing basswood left in center of strip—Phase III.

Fig. 4.—Turn of tree-length sticks coming into the landing—Phase III.

Phase II—1953: In order to provide for faster bunching, it was planned that in the second phase of this project, bucking into 8-foot lengths should be done in the woods. Since a desirable residual stand would still be too dense to permit the maneuvering of the skidding tractor, some way had to be provided to get the wood to prepared skid trails. The fellers were instructed to build small piles of from three to ten sticks oriented so that the entire pile could be winched to the skid trail. This, it was felt, would give almost the same effect as tree-length bunching, except that the trees would be "telescoped," and thus easier to handle.

At the skid trail, the sticks were to be loaded onto a specially built rocking-bunk dray which would permit quick unloading of a chain-wrapped dray load at the landing by the tractor driver alone. In order to facilitate the loading of the dray as well as to give a "high-lead" effect to the winch line, a swinging boom was built onto the rear of the skidding tractor.

Again the density of the residual stand, together with the stumps and slash created by the cutting, slowed the movement of the wood to the skid trail from where it was piled so that economical man-hour production was not achieved.

Further, with drays confined to prepared skid trails, the trails wore out long before the planned volume of wood had been moved over them. When the ruts got so deep that the drays were hanging up on stumps cut flush with the ground, skidding time became excessive. The density of the residual stand prevented more than occasional relocation of skid trails to avoid worn-out spots.

The crew consisted of 3 fallers, 1 tractor driver, 1 choker-setter, and 2 buckers. Production amounted to only .09 cords per man-hour (11.2 man-hours per cord) and .65 cords per machine-hour (1.5 machine-hours per cord).

Phase III—1953–54: Analysis of of the previous phases of this study showed that the most costly part of the skidding operation was that which required the movement of wood from where it was felled to where it could be accumulated into a bundle which would be economical to handle with mechanical equipment. In other words, bunching to the skidding equipment was too time-consuming.

This situation was due almost entirely to two factors—(1) a light cut, with the residual stand and the stumps of the trees making transportation of wood extremely difficult anywhere except on prepared skid-trails, and (2) the value of the individual pieces being harvested was so low that it did not permit much time or effort to be spent in gathering them together in a bundle big enough to pay its way through the rest of the harvesting process.

One way to overcome these difficulties which suggested itself was to eliminate the movement from the point of felling to the skid-trail. At first glance, it would appear that to do so would be incompatible with our objective of thinning the stand. Further examination of the idea, however, led to the conclusion that at least some of the benefits of a thinning might be achieved if the stand were cut in narrow strips. Such a plan would free the "edge" trees from competition on one side, and would concentrate in a small area the trees which were removed, permitting more economical bunching and skidding. The narrower the clear-cut strips, the more of them there would be per forty, and the more "edge" trees there would be.

Three strips, 15 feet wide with 30-foot uncut strips between them, were laid out in late 1953. One strip 20 feet wide was also laid out, with a "leave" strip of 40 feet. These strips were cut using Senior students from the Forestry Department of the College for labor. Trees were skidded tree-length to the landing, where they were bucked into eight-foot lengths and piled in one-half to one-third cord piles. Sufficient promise of reduction in logging cost was shown by this trial to justify a commercial type operation for the 1954 season.

Description of Logging Operation

In the previous two phases, all labor had been paid by the hour in order to provide for maximum flexibility in control of the method of logging. The trial of the strip-thinning method was sufficiently promising, however, to warrant handling this third phase in a manner more closely resembling a commercial operation. Consequently, two contracts were let, one for the felling, skidding, bucking, and piling, and the other for the loading, hauling, and unloading onto railroad cars. The Forest Products Research Division provided the skidding tractor, sulky, chokers, and bundling chains.

The crew consisted of three men. They felled, skidded and bucked until they had a carload accumulated, and then loaded and hauled. The equipment included:

1—One-man chain saw
1—Oliver OC-3 tractor with winch and dozer blade
1—Carco Jr. logging sulky (modified)
24—Grip-Trip bundling chains
1—A-frame jammer (truck-mounted)
1—1½ T truck
1—A-frame jammer (at RR siding)
1—H–D 7 tractor (power for RR jammer)
Chokers
Axes and miscellaneous tools

Felling: Lines 45 feet apart were run across the forty in a N-S direction, using a hand compass for maintaining direction and a spotting gun to mark the line. The faller was instructed to cut strips 15 feet wide, using these painted lines as center lines. He was further instructed to leave all basswood trees which did not interfere with skidding, as well as hard maple trees of particularly good form and vigor.

The result of these instructions was to produce five clear-cut strips, each a quarter mile long. Because of the bends in the strips to avoid trees intentionally left, as well as those to get around difficult terrain features, the strips do not give the appearance of a rigid, mechanically applied system.

Skidding: Tree-length skidding was used, with landings on each side of the forty. This resulted in a maximum skidding distance of 660 feet. Two landings served nine strips, and could have served another. For more than ten strips, it would be better to put in new landings.

Chokers were pre-set whenever possible, with the result that bunching time was cut to a minimum. The fairlead of the sulky had been raised a foot, giving better ground clearance to large bundles of trees. This modification caused the sulky to be a little more unstable, but not so much as to require any corrective measures.

A crew consisting of a choker setter and a tractor driver handled the skidding. When the landing got plugged up, they would help the bucker pile the sticks in ¾-cord piles.

Bucking and Piling: The bucking was done at the landing, and was done by the same man who did the felling. He would fell enough trees to keep the skidding crew busy for a while, and would go back to the landing to buck the trees as they were skidded in. He could get well ahead of the skidding crew while they were engaged in loading and hauling.

Depending on the skidding distance, ease of skidding, and size of trees, the choker setter would sometimes help the bucker, leaving the tractor driver to set his own chokers. Piling was done by the bucker with whatever help the tractor driver and choker setter could give him. Two Grip-Trip bundling chains were placed around each of the first twelve piles as they were made. The rest of the piles were spaced to permit the later placing of chains after they had been brought back from the railroad landing.

Loading, Hauling, and Unloading: A separate contract was let for this part of the operation. A truck-mounted A-frame jammer was used for loading the bundles onto a truck, four or five bundles constituting a load. After a 10-mile haul to the railroad, the bundles were lifted from the truck onto gondola cars with a tractor-operated A-frame jammer. The chains were removed from the bundles after they were placed in the cars.

The contractor provided the woods jammer, truck, tractor for operating the railroad jammer, and the necessary labor.

Results of Operation

Felling: Cutting in strips makes the felling considerably easier than when selective thinning is practiced. The easiest way, of course, is to drop the trees into the cleared strip, but in a "hot" logging operation this means felling most of them with the tops toward the landing.

Experience in the autumn of 1953 indicated that it is usually possible to find or create openings short distances ahead (in the direction of cutting) into which trees can be dropped with their butts toward the landing. Cutting then proceeds back toward the cleared strip. With experience, the faller can estimate quite accurately how far ahead each "jump" should be.

The contractor who did the felling this year was an experienced pulpwood cutter but had never had any experience with strip thinning. He could not be convinced that the little bit longer time spent in felling in the manner described above would be more than made up in ease of bunching and skidding if the butts were toward the landing. The result, therefore, was that the skidding was not quite as efficient as it might have been.

The team, consisting of a faller, a choker setter and a tractor driver worked out satisfactorily because they all pitched in and helped wherever the work was piling up.

Bunching and Skidding: It was in the interest of reducing bunching time that the idea of strip thinning was first considered. In this respect, the method lived up to expectations. Average bunching time was 9.7 minutes per cord, a reduction from 19.1 minutes in Phase I (Tree-Length Skidding), and 30.8 minutes in Phase II (Dray Skidding). This was the result, of course, of having the trees to be bunched concentrated on a 15-foot wide strip.

Both snatch-block and sliding-hook chokers were used, permitting the gathering together of the entire load in one pull of the winch in nearly every instance.

The skidding equipment, tractor and sulky, stayed on the clear-cut strips. As the trees were limbed and topped, the slash was thrown or pushed to the edges of the strip, or partly into the uncut strip, leaving in effect a cleared skid trail. In stands of this nature, and utilizing to a two-inch top, there is relatively little slash developed, since limbs and tops are small.

The stumps left in the cleared strips did interfere somewhat with the ease of driving and maneuvering the tractor and sulky. A power saw with a center-mounted blade had been used for the felling, with the result that stumps were higher than they would have been had a saw with a side-mounted blade been used. While the stumps did not cause the tractor to hang up, they were high enough and numerous enough to interfere with the tracks in maneuvering.

As mentioned earlier, many of the trees were felled with their tops toward the landing. This caused two things to happen which did not interfere with the skidding to any great extent but were a considerable nuisance.

In the first place, choking the tops frequently permitted trees to drop out of the load on the way to the landing. Second, the tops were so limber that with the longer trees much of the lifting effect of the sulky was lost, and the sliding resistance of the load was increased. Had the trees been felled properly, the average load taken to the landing might have been slightly larger, resulting in a more efficient operation.

Bucking and Piling: Having the bucking done by the same man who did the felling worked out quite well. He could not buck and pile by himself and keep up with the skidding crew, of course, but the operation balanced itself by having one or both members of the skidding crew help with the piling as required.

If the skidding distance was short, and the skidding easy, the landing would get plugged up quickly and both the tractor driver and choker setter would help the bucker. At other times the choker setter might stay on the landing for a few turns, helping the bucker while the tractor driver set his own chokers and brought in the loads.

Using the snatch-block type of choker made this arrangement possible, because once the chokers were in place, the entire load could be drawn up to the tractor with a minimum of maneuvering and adjustment. The only time lost was that spent in actually setting the chokers.

Summary

In 1952 the Cliffs–Dow Chemical Co., Marquette, Mich., requested that the Forest Products Research Division, Michigan College of Mining and Technology, undertake a project aimed

Table I.—COMPARISON OF MAJOR FACTORS AFFECTING COST OF FELLING, BUCKING, SKIDDING AND PILING THINNINGS FROM YOUNG SECOND-GROWTH HARDWOOD STANDS

	Phase I Tree-Length Skidding	Phase II Dray Skidding	Phase III Strip Thinning
Man-hours per cord	8.1	11.2	4.6
Machine-hours per cord	1.7	1.5	1.1
Production per man-day	.9 cds.	.7 cds.	1.7 cds.

at the development of economical means for harvesting thinnings from young hardwood stands. Success in such a project would not only make available to industry a large source of raw material which, for the most part, is economically inaccessible at present, but would also permit highly desirable early silvicultural treatment of second-growth hardwoods.

Wood was to be produced in 8-foot sticks and it appeared that bunching and skidding operations offered the best opportunities for significant cost-reducing developments. It was further realized that the obstacles of small size of timber, light scattered cut, and low value of product would somehow have to be surmounted or circumvented if logging costs were to be reduced.

The initial attempt employed tree-length skidding to a woods landing, where the trees were bucked into 8-foot lengths and bundled for further handling. The density of the residual stand, which was a function of the small timber and the light scattered cut, prevented the economical employment of the tree-length system. Bunching was so slow that production amounted to only .9 cord per man-day.

The second attempt relied on the formation of bundles of wood earlier in the operation to permit economical handling. The bucking was done at the time of felling, and small bunches of sticks were winched to the skid trail, where they were loaded onto a rocking-bunk dray. Once again the density of the residual stand caused the time for gathering wood to the skidding tractor to be excessive, with the result that production amounted to only .7 cord per man-day.

The third method tried, strip thinning, achieved production of 1.7 cords per man-day by reducing bunching time to an average of 9.7 minutes per cord as compared to 19.1 minutes with the tree-length method and 30.8 minutes with the dray-skidding method. In this phase of the study, nine 15-foot strips, each a quarter of a mile long, were cut, producing 103 cords of chemical wood. With this amount of experience, the men doing the work could hardly be called experts. It is to be expected, therefore, that as the method is used, costs will be reduced still further.

Since the operation which finally reduced the cost of harvesting to a reasonable figure involves a departure from conventional silviculture, the economic advantages of the method alone are not sufficient to permit its unqualified recommendation. Silvicultural studies in the form of permanent growth plots in the strip thinning system have been started. Final recommendation of the method must await the outcome of these silvicultural investigations.

Conclusions

Based on the information in Table I, the cost per cord of producing chemical wood by the three methods tried is as follows:

	Phase I	Phase II	Phase III
Felling, Skidding, Bucking and Piling:			
Machine cost (@ $1.20/hr.)	$ 2.04	$ 1.80	$ 1.32
Labor (@ $1.25/hr.)	10.12	19.00	5.75
Workmen's Compensation Insurance	1.62	3.00	.90
Loading, Hauling, Unloading (Contract)	4.00	4.00	4.00
Stumpage	.50	.50	.50
	$18.28	$28.30	$12.47

It is clear from the above that conventional thinning of young hardwoods for chemical wood is not economical on a commercial scale under present conditions of utilization.

While the figure given for Phase III falls approximately $1 short of the current price for chemical wood ($11.50 per cord f.o.b. cars), it does approach the goal closely enough to permit the recommendation that the strip thinning method be tested on a much larger scale, especially in view of the fact that further practice is certain to reduce costs. Although the effect of the method on rate of growth of the stand is not known, there would appear to be nothing to alter this recommendation from the silvicultural standpoint.

Discussion

F. C. Simmons (Northeastern Forest Experiment Station): This strip system of cutting is the only economical method of thinning many softwood plantations. Apparently it promises to be a profitable way to log small hardwood stands as well.

J. B. Veach, Jr. (Bemis Hardwood Lbr. Co.): What is the volume removed?

Mr. Toole: Almost the same in each instance—approximately 8 to 10 cords per acre, or about one-third of the stand.

G. Stenzel (U. of Washington): Was there any windthrow or snowthrow on the edges of the cutting

Mr. Toole: None at all so far. Since the strips are still well protected within the general stand, windthrow or snow damage will probably be normal.

Peter Koch (Mich. State U.): Would a narrow width be better?

Mr. Toole: The width of strip could be varied readily to meet specific silvicultural objectives, operating requirements, or stand conditions. A narrower strip might be desirable in a younger age class or smaller size class stand.

W. J. Tomford (James E. Stark Lbr. Co.): Are insurance companies in that area writing compensation insurance for these small jobber operations? In the South we have difficulty obtaining coverage for small logging contractors operating as individuals.

Mr. Toole: Yes, several companies will write compensation insurance for these jobs. The cost of workmen's compensation adds considerably to the above figures—$3 per cord in the second method tried. However, many small jobbers are paying it on pulpwood and logging jobs. In some cases the purchasing organization insists on the coverage.

Economics of Debarking Redwood Logs[1]

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Presents information available on suitable methods for whole log debarking of redwood logs, and evaluates benefits that may result. The results show that value derived from whole log debarking more than offsets cost of any of methods studied. Hand barking at prepared mill landing is most economical for mills with daily production of 200 M bd. ft. per day or less, hydraulic debarkers promise to be more economical for higher daily production levels.

Introduction

ONE OF THE MOST PERPLEXING PROBLEMS confronting the redwood sawmill industry is that of economical removal of bark from redwood logs. Until recently, unlike other regions in our forest products industry, the search for an economical method of bark removal was not in any manner predicated on the recovery of usable mill leftovers such as trim, edgings, and bark for further processing. Outlets for this material are still not extensive in the redwood region. The primary reason for debarking redwood logs lies in the character of the bark.

Recent studies (1, 2)[2] state that redwood bark ranges from 1 to 7 inches in thickness measured on one side of the log. The volume of bark amounts to approximately .15 cords per M bd. ft. of logs, Humboldt Scale. Redwood bark is an extremely tough, fibrous material which tends to come off the log in long strips. If unbarked logs are permitted to enter the mill, the bark separates into long, stringy bundles of fibers which wrap around saw teeth, rolls, conveyor chain sprockets, and other equipment in the manufacturing process. This causes saws to overheat and snake in the cut; clogging of rolls which causes bearings to overheat; and fouling of conveyor sprockets forcing conveyor chain off drive wheels which may cause complete stoppage of the mill. This results in lower production, decreased quality of product, increased maintenance, decreased safety, and shorter equipment life

The problem of economical removal of redwood bark has received considerable attention in the past decade. Most of this, however, has been on an individual mill basis. In recent years, several manufacturers of heavy machinery have concentrated on the problem of bark removal in general. Owing to the limited market, most of these firms have been reluctant to invest in the experimental programs necessary for developing an effective redwood log barker. However, it has been established that actual removal of bark from redwood logs may be accomplished effectively by the methods developed for use on other species in the Pacific Northwest.

The machinery now available has several limitations. None of the present whole log barkers take full advantage of the "stripping" characteristics of redwood bark. The equipment available, with one exception, erodes or scrapes away the bark reducing the bark to a mass of tangled fiber. This causes clogging of the machine and results in considerable reduction in efficiency. Most of the machines will not dispose of strips of bark once the strip is removed from the log which often happens in the summer peeling season.

In addition to the above limitations, which could be overcome, the cost of this equipment is relatively high. Cost of barking by mechanical or hydraulic methods has been considered excessive for the size of mill commonly found in the redwood region. Development of machinery for debarking redwood logs continues to receive attention from various manufacturers.

In the absence of more economical methods of log barking by mechanical or hydraulic means, hand barking of redwood logs continues to be the method most used. This method is not satisfactory however, as peelers are often hard to get and complete bark removal is impossible if done in the woods. Hand barking at a central plant having log turning equipment is more satisfactory. The problem of obtaining peelers still remains, and labor costs continue at a high level.

The purpose of this paper is to summarize current thought on this problem through:

1. Evaluation of benefits to be derived from the barking of redwood logs;
2. Determination of the justifiable expenditure for log barking for various levels of mill production;
3. Summarization of existing methods of log barking as to operation, limitations, and cost;
4. Determination, within limits, of the most economical method of log barking for various levels of mill production in the redwood region.

Log Barking

The benefits to be derived from whole log debarking are several and will be evaluated here insofar as it is possible to establish a monetary value. These benefits may be summarized as follows:

1. Greater production due to increased sawyer efficiency and less down time;
2. Greater recovery;
3. Increased production of higher quality lumber;
4. Lower saw maintenance and longer saw life;
5. Lower charges for clean-up and general maintenance;
6. Greater safety;
7. Utilization of mill leftovers.

Greater Production: Greater production per man is estimated at 10 per cent for most operations (3). This increased production is due to increased sawyer efficiency, less lost time handling logs, fewer mill stoppages for saw changing, clogged conveyors, and debris in the mill. Of this 10 per cent, increased sawyer efficiency and mill cleanliness account for 6 per cent and fewer saw changes accounts for 4 per cent.

Greater Recovery: Estimates of increased recovery (overrun) from the log vary from 6 to 15 per cent (4). The increased recovery is the result of the removal of thinner slabs, lower production of "snaky" lumber, and more accurate sawing. An increased recovery of 6 per cent is used in estab-

[1] Presented by title only at Session III, Logging and Milling, Ninth National Meeting, Pacific Logging Congress, June 21–24, 1955, in Seattle, Wash.

[2] Numbers in parentheses refer to literature cited.

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lishing the monetary value of this benefit.

Increased Production of Higher Quality Lumber: Upgrading results from the sawing of thinner slabs which increases the production of higher grades from the outer portion of the log. Also, the sawyer is better able to size up the log, permitting the use of a more accurate method of log breakdown for maximum value recovery with no sacrifice of production. Upgrading has been estimated at 5 per cent (5). A conservative value of 2 per cent is used in calculating the monetary value of this benefit.

Lower Saw Maintenance and Longer Saw Life: Most operations sawing bark-free logs report a reduction in saw maintenance. This is most evident when debarking is accomplished at the mill since rocks and other foreign objects that become embedded in the bark in logging are removed in the barking operation. Also, it is much easier for the sawyer to detect tramp metal before saws are damaged. At least one operation reports no change in saw maintenance.

It is generally agreed that sawing bark-free logs increases saw life. Approximately 10 per cent longer saw life is reported (6).

Lower Charges for Clean-up and General Maintenance: Charges for general mill maintenance and clean-up are decreased due to less debris entering the mill. Fewer men are required for clean-up and there is less misuse of equipment. For instance, roll case bearings overheat when rolls are fouled by bark, necessitating more frequent maintenance. Equipment life should increase materially if no bark is permitted to enter the mill. No figures are available to indicate the value of this advantage.

Greater Safety: It is not possible to accurately evaluate this item monetarily. However, it is generally agreed that safety is increased considerably due to more efficient log handling, less saw breakage, easier detection of tramp metal, and less debris in the mill. Records of one operation (6), show six lost-time accidents totaling 120 man-days in a two year period which were directly attributable to bark. Bark may have contributed to other lost time injuries and to many "no lost time" injuries. It is obvious that factors contributing to a lesser degree of safety are expensive both in production and employee morale.

Utilization of Mill Leftovers: It was stated previously that recovery of useable mill leftovers is not the primary factor behind the need for debarking redwood logs. However, it would be in error to ignore the possibilities of utilizing the clean mill leftovers that result from sawing bark-free logs. The return from the sale of these products could then be used to offset the cost of debarking.

Two types of sawmill leftovers from redwood logs will be discussed. These are the slabs, edgings and trim, or chippable waste, and redwood bark.

Chip Production: The market for redwood chips, while not yet extensive, is expanding. Due to the limited market, periods of temporary market saturation may be experienced in the near future. These periods of market saturation should decrease as the use of redwood chips increases and production of chips becomes stabilized. Accordingly, a brief analysis of the production of chippable mill leftovers is presented here.

The reported production of chips from leftovers in Douglas-fir is .67 units per M bd. ft. log scale if whole log barking is used. Chip production from unbarked Douglas-fir logs is approximately .25 units per M bd. ft. log scale, if only clean chippable wood is picked from the waste conveyor (7). The consensus of the Redwood Sawmill Committee is that the chip production reported for Douglas-fir is low for redwood. The reason for this is that there is more bark-free waste wood in redwood logs. The maximum chip production that may be expected from bark-free redwood logs is estimated as follows:

Clean wood from unbarked logs	.25 units M bd. ft.
Expected loss of wood due to shake, rift cracks, etc. 30%	.45 units M bd. ft.
Runout 8%	.10 units M bd. ft.
Total estimated production	.80 units M bd. ft.

It should be stressed that the above recovery is the estimated maximum that may be expected. Further, it is recognized that a more useful figure would be the minimum recovery that could be expected. However, this figure depends on the condition of the logs as to defect, log size, accuracy in sawing, lumber sizes produced, and many other factors which are determinable only for individual operations.

Chip production, cost per unit produced, and gross profit per unit is shown in Table 1 for various levels of mill production. These figures are based on a maximum chip production of .80 units per M bd. ft. of logs, Spaulding Scale, when using a whole log debarker or other suitable means to remove all the bark from the log.

Maximum chip production from unbarked or partially barked redwood logs is estimated at .55 units M bd. ft. of logs, Spaulding Scale. The minimum chip production from unbarked or partially barked redwood logs is estimated at .35 units per M bd ft. log scale.

For this analysis, the cost of the chipping plant is estimated at $55,000 for a 72-inch chipper and all equipment, installed, complete. It is assumed that two such installations would be required to chip all mill leftovers in those mills where the chip production would exceed 200 units per day.

Further analysis of the economics of chip production from redwood may be found in CRA Research Project Index No. 3.82000-A.

Bark Production. The utilization of redwood bark is not extensive. This material is processed in only one or two plants in the redwood region and adjacent areas. Redwood bark fibers are effective as insulation mulches, fillers for other fibers, and many other uses not fully developed. With a production of 0.15 cords per M bd. ft. log scale and a log usage of 900 MM bd. ft., the annual production of redwood bark is 135,000 cords.

It is to be expected that utilization of this product will increase as more uses are developed for it. Consideration should be given to the possibilities of sale or processing of this material in determining the method of debarking to be used. No analysis of expected return will be given here due to the limited market.

Justifiable Expenditure For Debarking

All of the benefits that may be derived from whole log debarking are not subject to a monetary evaluation.

Table 1.—CHIP PRODUCTION, COST PER UNIT, AND GROSS PROFIT PER UNIT FOR VARIOUS LEVELS OF MILL PRODUCTION

Daily Mill Capacity M bd. ft.	Daily Chip Production Units*	Cost Per Unit $	Sales Price Per Unit $	Gross Profit Per Unit $	Gross Profit Per Day $
70	56	3.83	6.00	2.17	122
100	80	2.68	6.00	3.32	266
125	100	2.14	6.00	3.86	386
150	120	1.79	6.00	4.21	505
200	160	1.34	6.00	4.66	746
250**	200	1.07	6.00	4.93	986
300	240	1.79	6.00	4.21	1010
350	280	1.53	6.00	4.47	1252
400	320	1.34	6.00	4.66	1491

*Based on a maximum chip production of .80 units per M bd. ft. sawn.
**Two 72-inch chippers would be required if chip production exceeded 200 units per day.

A sample calculation of these benefits that may be readily evaluated is shown below.

Assuming a daily log usage of 100 M bd. ft. from unbarked logs, the calculation is as follows:

Benefit		M bd. ft.	Value
Greater production due to:			
Increased sawyer efficiency	6%	6.0 @ $15/M	$ 90.00
Less down time	4%	4.2 @ $15/M	63.00
Greater recovery	6%	6.6 @ $80/M	528.00
Increased quality due to upgrading	2%	2.3 @ $15/M	34.50
Total Daily Return			$715.50

This calculation shows that in changing from sawing of non-debarked logs to the sawing of fully debarked logs, an increase in production of 16.8 per cent may be expected from a 10.2 per cent increase in log usage. Further, that an increase in value return of approximately $7.15 per M bd. ft. would result from this change is apparent, when value return from chip production is not considered. Where all leftovers may be chipped, the increase in daily value return is estimated at $10.81 per M bd. ft.

It should be noted that the justifiable expenditure per day for whole log debarking is considered as equal to the sum of the estimated value of the benefits of whole log debarking. For those mills sawing partially debarked logs, the full increase in daily return from log barking would not be realized by improving the debarking operation to remove all the bark. In other words, if a mill now saws logs that are 80 per cent bark-free, it is assumed that approximately 80 per cent of the value of the benefits of debarking are being realized.

It should be remembered that the evaluation of the benefits of whole log debarking is, with the exception of chip production, based on the minimum expected return from the various benefits. For instance, greater recovery is estimated at 6 per cent to 15 per cent. Reference to the sample calculation will show that the minimum figure of 6 per cent is used.

Conversely, in estimating the return from chip production, the estimated maximum chip production is used because an accurate minimum chip production from bark-free logs is determinable only for individual operations.

Method of Barking

Three methods of whole log debarking will be described briefly. These are hydraulic, mechanical, and hand barking. Descriptions of available equipment for each method of whole log debarking will be given. The intention is to present equipment that has proven sound in principle for use in debarking redwood logs. Machines other than those presented may be suited to use on redwood logs. Omission of such equipment is due to the absence of specific information on such equipment.

Hydraulic Debarkers: Hydraulic whole log debarkers depend on the energy exerted by jets of water flowing at high velocities to remove the bark from a log. Bark removal is accomplished through the eroding and lifting of the bark by the jets impinging on the log surface. This action has a relatively low mechanical efficiency.

The advantages of this method are:

1. High efficiency, as measured by percentage of bark removed;
2. No wood loss if operated properly;
3. High production;
4. Efficient removal of surface decay;
5. Conventional log-handling equipment may be used.

The disadvantages are:

1. High cost of equipment;
2. A large volume of clean water is required;
3. Low mechanical efficiency;
4. Bark coming from the barker is wet, which reduces its value for fuel or by-products.

The estimated production per day from existing hydraulic equipment is shown in Table 2. An average feed speed of 15 fpm is assumed.

Four machines are now available and considered suitable for use on redwood logs. These are the Hansel Ring Barker, the Simons Hydraulic Barker, the Bellingham Barker, and the Hansel Trunnion Type Barker. The Hansel Pantograph-arm Barker is suited in principle for use on redwood but several changes in design are considered necessary for efficient operation on redwood logs. Another hydraulic debarker, the Rambo Hydraulic Barker, has been designed but is not yet under production.

Table 2.—ESTIMATED DAILY PRODUCTION OF HYDRAULIC BARKERS

Average Log Volume fbm	Daily Production M bd. ft.
600	216
800	288
1000	360
1200	432
1400	505

Mechanical Debarkers: Mechanical methods of whole log debarking have not found as wide use on the large logs of the Pacific Northwest as have the hydraulic types. This is due in part to the wood loss associated with mechanical methods of bark removal. Wood losses as high as 15 per cent have been reported when the cutterhead type of mechanical debarker is used. Most whole log barkers are installed in conjunction with chipping plants, and any wood loss is expensive if all mill leftovers are marketable as chips.

Another reason for the wider use of hydraulic whole log barkers is the relatively low production of mechanical barkers. The optimum daily production of existing mechanical barkers appears to be in the 70–100 M bd. ft. range when barking redwood logs.

The action which removes the bark is a cutting or crushing and tearing of the bark, or a combination of these actions. At least one design depends solely on cutting action. Others use compression or crushing and rubbing friction to accomplish bark removal.

The advantages generally attributed to mechanical methods of bark removal are:

1. Low capital and operating cost;
2. Usually simple design requiring little maintenance;
3. High mechanical efficiency as compared to hydraulic types;
4. Water used as a wash does not require extensive preparation.

The disadvantages of this method are:

1. Relatively low production;
2. Wood loss may be serious if chipping facilities are available;
3. Tendency to foul with fibrous redwood bark;
4. Will not handle chunks, cants, or very crooked logs;
5. Bark removal is not complete on rough or fluted logs without considerable wood loss;
6. Continuous preventive maintenance is required with some designs.

Several mechanical whole log barkers are available. One design utilizing a cutting action is now in use on redwood logs and is considered successful. The principle used for bark removal on several lathe-type machines, namely, a crushing and scraping away of the bark, is also suited to use on redwood. While the lathe-type machine is not practical for use on saw logs, three machines which use this principle of bark removal are available. These are the Nicholson Rotobarker, the Anderson Debarker, and

Table 3.—HAND BARKING DATA SUMMARY

Barking	Number of Logs	Average Diameter (i.b.)	Average Bark Thickness	Efficiency	Man-hrs/M bd. ft. actually barked	Cost per M actually barked (labor and equip.)
In woods:						
Mill "C"	101	33"	1.93"	63%	0.52	$2.46
Mill "U"	119	50"	2.22"	62%	0.36	$1.70
Mill "W"	99	68"	2.70"	63%	0.24	$1.71
Average	106	50"	2.28"	63%	0.37	$1.96
At a prepared mill landing:						
Mill "M"	99	43"	1.94"	82%	0.34	$2.94
Mill "V"	101	54"	2.06"	80%	0.32	$1.29

the Burnt River Lbr. Co. barker manufactured by the Sumner Iron Works, Everett, Wash.

Hand Barking (8): No entirely satisfactory method of debarking redwood logs by mechanical or hydraulic means has been developed. The primary difficulties are the disposal of the bark once it is removed from the log and the usually high cost of equipment with sufficient size and productive capacity. In the absence of more economical methods of whole log debarking, hand barking of redwood logs is the method most used.

Hand barking of redwood logs is characterized by a very efficient use of power. That is, a man exerting ¼ h.p. can debark approximately 30–40 M bd. ft. Humboldt Scale per day while typical hydraulic and mechanical whole log debarkers requiring up to 8000 times as much power, debark only ten to twelve times as much volume. Hand barking methods, therefore, have a relatively high mechanical efficiency. However, when measured by cost per h.p. and adjusted for efficiency of bark removal, the mechanical and hydraulic whole log barkers assume a more favorable position, particularly for daily productions in excess of 200 M bd. ft.

Redwood logs are hand barked either in the woods where the tree falls or at a prepared mill landing. Time studies of each method were conducted to determine the time required per M bd. ft. debarked, the efficiency as measured by per cent of log circumference actually debarked, and the cost per M bd. ft. actually debarked for each method.

Debarking is accomplished by peelers working singly or in pairs using a simple spud or "peeling bar" and an axe. The action which removes the bark is a tearing or separation of the bark and wood at the cambium layer. As is the case with most other sepcies, bark may be removed from redwood more easily during the spring and summer season than during other seasons.

The primary advantage of hand barking is that the investment in equipment is usually negligible. This method is most economical for those mills with a comparatively low daily mill cut.

The disadvantages are:

1. Efficiency, as measured by per cent of log circumference debarked is lower than other methods in most cases;
2. Considerable labor force is required, and the availability of a labor supply fluctuates seriously.

Hand Barking in Woods: The advantages of this method of log barking are:

1. Bark is left in the woods requiring no investment in plant and handling equipment;
2. The cost of hauling the bark to the mill is avoided;
3. Certain types of logging equipment handle the log more efficiently when the bark is removed.

The disadvantages are:

1. It is low in efficiency as measured by percentage of log circumference actually barked;
2. Bark left in the woods contributes to the fire hazard;
3. Accumulated bark debris may hinder reproduction;
4. It is often more hazardous than log barking at a prepared mill landing due to bad lie of logs, slippery log surface, and accumulation of logging debris;
5. The slick surface of the logs present handling problems with some types of equipment;
6. Surface checking may cause some loss;
7. Rocks may become embedded in the surface of the log, causing damage to saws.

Hand Barking at a Prepared Landing at the Mill: The study of hand barking included two systems of hand barking at prepared mill landings. The two systems vary considerably in detail and will be discussed here only as to general function.

Each of the two methods consists of log conveying devices for positioning the log, log turning equipment to permit the barking of the bottom as well as the top and sides of the log, and suitable equipment for bark disposal to prevent congestion in the work area.

The log conveying and turning equipment may be standard log conveyor chain, cable slings, hooks, etc., depending on the individual installation. Bark disposal may be accomplished by burning, utilization, or other suitable methods.

Several advantages may be stated for this method of log barking:

1. Complete bark removal is possible;
2. Bark can be accumulated for processing;
3. Greater safety compared with hand barking in woods;
4. The fire hazard in the woods is reduced;
5. Removal of bark from the woods aids reproduction;
6. Surface checking of the logs is prevented;
7. There is less chance that foreign materials will become embedded in the log.

The disadvantages are:

1. An investment in plant and equipment for log handling and bark disposal is required;
2. Bark sometimes increases the difficulty of handling logs in the woods;
3. An additional cost of transportation is incurred in hauling the bark to the mill.

Several of the advantages of hand barking at a prepared mill landing are inherent in any method of barking at or near the sawmill. These advantages are stated for this particular method as a comparison with hand barking in the woods.

The results of the study of hand barking are summarized in Table 3.

Chemical Debarking: Considerable interest has been evidenced in the chemical debarking of redwood logs. This method is used extensively in pulpwood forests in the eastern United States. The method consists of girdling the tree and placing various poisons around the tree in the girdled area. This causes the tree to die and the bark then separates from the wood.

This method is not considered suitable for use on redwood. The girdling and killing of the tree by poisons may prevent reproduction by sprouting and the thick bark which would normally cling to the tree would be dangerous in the felling operation. The cost of this method would be relatively high for a thick-barked species such as redwood.

Cost of Barking

A typical cost estimate for each method of barking is shown in the appendix. These and other estimates are summarized in Figure 1.

Recent developments in hydraulic debarkers indicate that equipment may

now be available which will debark logs more economically than previous designs. Therefore, hydraulic debarkers have been segregated into two groups. Group 1 includes the Hansel Ring Barker, the Bellingham Hydraulic Barker, and the Simons Hydraulic Barker. Group 2 includes the Hansel Trunnion-type Sawmill Barker and the Hansel Pantograph-arm Sawmill Barker.

Mechanical debarkers are grouped together since analysis indicates that cost per M bd. ft. debarked varies but little between the different designs. Which is the more desirable machine within any of these groups appears to be largely a question of which design satisfies the conditions of the individual installation most thoroughly.

One instance of widely varying costs was noted in the study of hand barking in the woods. This, however, was due to the method of payment and reflects the difficulty of obtaining sufficient labor force. The cost shown for hand barking in the woods is an average of three operations.

Hand barking at a prepared mill landing may vary greatly in cost at different mills due to the varying amounts of investment in equipment for log handling. Two systems of hand barking at a prepared mill landing were investigated and are presented separately due to the extreme differences in capital investment and therefore, in total cost per M bd. ft. debarked.

It will be noted that cost per M bd. ft. debarked does not vary with production in mechanical and hand barking methods. This is due to the fact that these costs are based on the expected production from the basic unit of equipment or manpower. To attain higher productions, the number of basic units employed must be increased. Cost per M bd. ft. debarked would increase slightly as production increases due to the fact that as basic units are added, additional maintenance and supervisory forces may be required. This is particularly true for those operations using hand barking, since the primary investment for the hand barking methods is usually in the labor force. Supervision becomes more important as the size of the labor force increases.

The advantages and disadvantages of each method of barking should be carefully studied in connection with the above costs if a change in debarking method is contemplated.

Experience has shown that the methods described will remove the bark from redwood logs. As previously stated, however, none of these are entirely satisfactory. The high cost of hydraulic debarkers, the low production of mechanical equipment, and the inefficient bark removal of some hand barking methods render them all unsatisfactory to some degree. The disadvantages stated for each method make it possible to outline the requirements for an efficient method of bark removal from redwood logs.

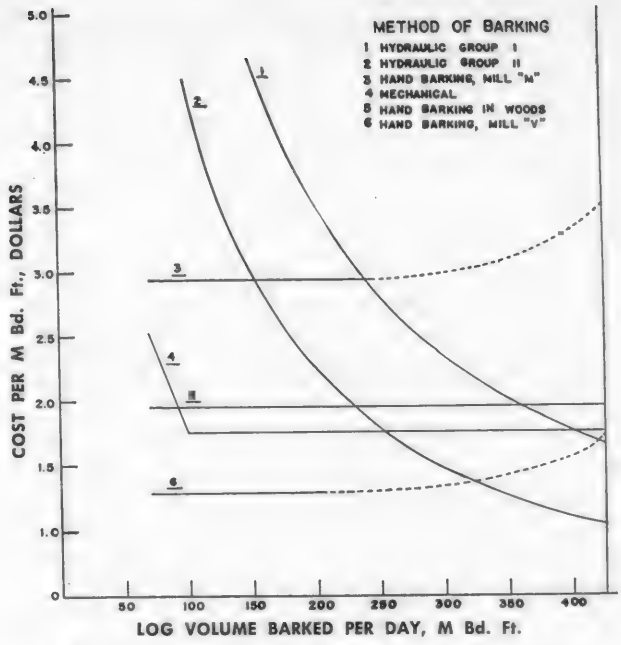

Fig. 1.—Cost of barking per M b.f. by various methods.

These requirements are summarized as follows:

1. The method should be one that will take advantage of the stripping characteristics of redwood bark;
2. It should be designed to dispose of log-length strips of bark as well as smaller pieces that may result from the barking operation;
3. It should be within the budget of mills of 100–200 M bd. ft. daily capacity and be of sufficient size to debark large redwood logs;
4. Hydraulic methods should utilize low water volume or be designed to use unfiltered pond water;
5. The method should not be based on the continuous turning of the log but indexing should be possible.

Literature Cited

1. Cull and breakage factors and other tree measurement tables for redwood. Forest Survey Release 13, California Forest and Range Experiment Station, Berkeley. p. 25.
2. Redwood bark thickness. Research Project Index 1.20121, Interim Report D. California Redwood Assoc.
3. Horne, Roy C. Log barking and barkers. Research Laboratory Note 42. Western Pine Assoc.
4. Proceedings of the 1951 sawmill operating conference. *The Timberman*, Nov. 1951.
5. Hansel, Sydney. 1952. Hydraulic barking. *Proc. FPRS.* II (5):106.
6. Sweetland, W. E. The cost of unpeeled logs. Union Lumber Company, Fort Bragg, Calif. Unpublished.
7. Rambo, W. H. and DeRice, H. A. 1952. Economics of log debarking in sawmills. *The Lumberman*, May. pp. 94–96.
8. Hand barking redwood logs. Research Project Index No. 3.11310, Interim Report A. California Redwood Assoc.

Appendix

The following are typical cost estimates for the various methods of barking that are suited to use on redwood.

HYDRAULIC

Equipment and Installation:	
Custom Barker: (18"–120" diam., 24' length)	$ 85,000
2 Bingham Multi-stage Pumps @ $9000	18,000
2 600 H.P. Pump drive Motors @ $7000	14,000
Barker Drive	2,500
Carriage Drive	2,500
Log Handling Equipment	20,000
Water System	40,000
Building	10,000
Installation (estimated as equal equipment cost)	192,000
Total	$384,000
Engineering 7.5%	28,800
Contingent 10%	38,400
Estimated Total Cost of Plant	$451,200

Cost per Day: (based on 250 days per year)

1. Capital charges on investment of $451,000 per day		
6% Interest	$108	
3% Insurance	54	
3% Taxes	54	
20% Depreciation	360	
		$576
2. Operating cost		
5% Maintenance	$ 94	
Power and Water	16	
		$110
3. Labor		
1 man @ 2.00/hr.	$ 16	
		$ 16
Estimated Total Cost Per Day		$702

Cost per M Board Feed: Assuming an average continuous feed rate of 15 fpm, the cost per M bd. ft. for various log sizes would be:

Average Log Volume	Volume per Day	Cost of Barking per M board feet
600	216,000 fbm	$3.25
800	288,000	2.44
1000	360,000	1.95
1200	432,000	1.62
1400	505,000	1.39

MECHANICAL

A complete installation of a typical mechanical whole log debarker is quoted at $80,000. Approximately 200 H.P. are required to operate the equipment.

Cost per Day: (based on 250 days per year)

1. Capital charges on investment of $80,000 per day		
6% Interest	$19.00	
3% Insurance	9.50	
3% Taxes	9.50	
20% Depreciation	64.00	
		$102
2. Operating cost		
10% Maintenance	$32	
Power	10	
		$ 42
3. Labor		
2 men @ 2.00/hr.	$32	
		$ 32
Estimated Total Cost Per Day		$176

Cost per M. Board Feet: Experience indicates that the optimum working point for the mechanical debarking of redwood logs is in the 70–100 M bd. ft. per day range. The cost per M bd. ft. for various daily productions is as follows:

Daily Production M bd. ft.	Cost of Barking per M board feet
60	$2.94
70	2.52
80	2.20
90	1.96
100	1.76

HAND BARKING

The following is a typical cost analysis for hand barking at a prepared mill landing. Method of analysis would vary with method of payment and equipment used.

Labor Cost Per M Board Feet Barked:

7 Peelers	@ 2.07/hr.	$14.49
1 Engineer	@ 2.09/hr.	2.09
1 Chain Saw Operator	@ 2.12/hr.	2.12
1 Supervisor	@ 2.40/hr.	2.40
Total 10 Men		
Total labor charge per man-hour		$21.10
Average labor charge per man-hour (10 men)		$ 2.11
Production per man-hour: (from time study data)		
Man-hours required per M bd. ft. barked		0.32 hr.
or		
M bd. ft. barked per man-hour		3.12 M bd. ft.
Average labor charge per man-hour		$ 2.11
Man hours per M bd. ft.		0.32 hr.
Labor cost per M bd. ft. barked		$ 0.675

Equipment Cost:

Two double-drum loading donkeys powered by 250 h.p. electric drive	$20,000	
Cable, equipment and installation	10,000	
Truck for bark disposal	3,000	
		$33,000
Contingent 10%	3,300	
		3,300
Total Cost of Equipment and Installation		$36,300

Cost per Day: (Based on 250 days per year)

1. Capital charges on an investment of $36,300 per day		
6% Interest	$ 8.72	
3% Insurance	4.36	
3% Taxes	4.36	
10% Depreciation	14.50	
		$31.94
2. Operating charge		
6% Maintenance and truck operation	$ 8.72	
Power	2.00	
		10.72
Total Daily Capital and Operating Cost		$42.66

Total Cost per M Board Feet Barked: Based on a daily production of 70,000 board feet, the total cost is as follows:

	Cost of barking per M board feet
1. Capital and operating cost	$0.61
2. Labor	0.68
Total cost per M board feet	$1.29

New Developments in Milling of Small Softwoods [1]

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The practical approach to the problem of sawing the small softwood log is attained by carefully analyzing all factors of production from standing timber to final product. Significant trends are apparent in western milling practice in respect to both the use of gang saws and bands saws for headrigs and in the automation of the small-log mill.

THE SAWMILLING INDUSTRY has been undergoing a gradual but continuous process of improvement in its manufacturing techniques since its inception on this continent in the early 1600's. In retrospect, the intervening 300 years have merely reversed the problem that confronted our pioneer lumbermen. The early sawmiller, favored with nature's gift of a bounteous forest, exercised the power of selection over the size and quality of raw material for his mill but he was restricted in his choice of equipment to that of a "home-made" nature. In contrast, today's lumber manufacturers are offered a wider selection in respect to machinery and equipment than in respect to log supply, and the new devices are far removed from their "home-made" progenitors in performance and efficiency.

A search for the new developments that are taking place in small-log processing does not indicate that the industry stands on the threshold of any revolutionary change in the three basic headsawing techniques of saw-

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ing lumber; namely, band sawing, circular sawing, and gang sawing. Instead. the investigator is impressed with the manner in which sawmill equipment has undergone a continuous process of improvement and modification—a process which has been greatly accelerated in the past decade. The past few years in particular have brought technological improvements to the field of production which can do much to help the industry successfully cope with the dynamic changes that are taking place in the cost of production, quality of raw material, and competition for markets.

Analyzing the Small-Log Problem

Management decisions leading to the selection of headrig sawing equipment are fundamentally governed by available investment capital. Significant among the new developments in softwood milling is the fact that all of the basic techniques can be tailored to meet the wide range of conditions confronting the industry. The trend toward high productivity through the mechanization of materials handling equipment is steadily becoming more evident in small and large mills alike. The practical solution to a specific small-log problem is found through the careful analysis of all factors of production from raw material to final product.

All planning logically starts with a study of the timber supply in respect to availability, size, and quality. From this information, the optimum board-foot output per shift is established, without particular thought as to the type of breakdown unit. The most advantageous type of headrig is determined next on the basis of the scale of the average log, the average lumber size (determined by the market for which the mill is to be built), the average lumber grade yield recovered by the several sawing techniques, and the overrun characteristic of the headrig units under consideration. From this statement it should not be construed that modern mills are designed for the average log, but instead that advance planning establishes an upper limit to the size of the log to be handled in the mill. Over-design in modern sawmilling to accommodate the occasional large log can be expensive. As proof of this statement, witness the downward design of the older large-log mills in the West as they move to sustain productivity with smaller, faster equipment.

One other facet of the small log problem that cannot go unstudied is the nature of the supporting uitilization. Herein lies the major departure between the planning deliberations of the purely small-log, low-volume operation and the small-log operation which is an integrated part of a company with sawing equipment for processing large logs.

The foregoing summarization reflects some of the more progressive present-day thinking in analyzing the small-log problem and establishes a basis for evaluating trends in modern small-log milling. The discussion which follows is developed essentially from observation and study of western milling practices and it is set forth here in the true dictionary sense of "argument for the sake of arriving at truth or clearing up difficulties".

Gang Sawing Trends

Field investigations and trade journal perusal point up a tremendous increase in the number of gang-mill installations during the past year. These installations range from daily capacities of 25 M to 100 M board feet, although the latter figure is not common. The most common application of the gang saw appears to be in the mills of 40 to 80 M feet capacity. The lower limits of this mill-size class are being defined somewhat by limitations in sorting to favorable log sizes for extended sawing without sash changes, and the upper limits by the difficulty of logging the high volume of small logs required to sustain a lumber production of much greater proportions.

The gang installation in the medium and upper range of the 40 to 80 M feet per day class is readily justified, particularly when the mill sustains an adequate inventory of timber and logs. The full advantage of the gang can be realized under these conditions if the added precaution is taken to sort logs prior to sawing to diameter classes of minimum practical limits. Manufacturers of gang saws indicate that it is difficult to educate mill men on the benefits of this phase of gang sawing. In the smaller mills much grade and footage is lost when low inventory prevents log sorting into advantageously small diameter classes.

Several trends can be detected in the installation of gangs but none appear to have emerged as a panacea for the industry. Smaller mills in the 30 to 40 M feet per day class show a perceptible tendency toward replacement of conventional mills with round-log gangs, although the gang-mill supplement to the circular headrig receives almost equal favor in this group. The straight round-log gang mill in this range of production is seemingly in the twilight zone for gang-mill operation. Many mills in this class are committed to low production simply because they lack timber holdings and find it impossible to maintain sufficient inventory to practice effective log sorting and to operate at the more efficient rate of the larger operation.

Many large mills equipped with band headrigs have turned to the round-log gang as the solution of their small-log problem. The small logs with little or no clear are routed to the gang, while the large logs and small logs with grade potential are sawn on the band headrig. The use of the round-log gang saw in western sawmill practice can hardly be termed a new development but it seems appropriate to report its increasing popularity and take cognizance of the trend.

Although this report is committed to the subject of milling small logs, a point worthy of mention became self-evident in the study of the problem. It concerns the handling of intermediate diameter logs in the range of 18 to 24 inches. Modern mill-study data which cover lumber grade yields for the several western species in this diameter class are lacking. Many mills with the option of band sawing tend to route logs with diameters up to 24 inches to the gang saw. In view of the high productivity and grade recovery characteristics of the modern small band mill, the economics of the problem becomes an excellent subject for new research and the information would be most welcome to management who are faced with the problem of integrating a small-log operation into an existing mill.

Automation in Small Log Mills

New developments in sawing small logs on a conventional carriage are mainly in the realm of mechanizing log handling on the mill deck and log carriage. Automation of the small and intermediate carriage sawing mills which started at the end of World War II has gathered momentum in the past few years. The growing number of competent sawmill engineering firms that design both effective equipment and efficient sawmills forecasts even more spectacular advances in automation in the near future.

In many other industries the automatic factory is not merely coming, it is already here. In typical fashion our industry lags the field in exploiting technological progress in automation but there is tangible evidence of a quickening movement in the right direction. The industry has followed the pattern predicted by Matthew J. Murphy in "Problems in the Push-Button Factory" when he stated, "Automatic production will undoubtedly be a slow, creeping revolution for most plants and managements. But a revolution it will nevertheless be—in industrial relations and in management's own attitudes".

The pioneering in sawmill automation is well underway. The riderless

carriage, introduced but a few years ago, is well on its way to becoming standard equipment in the progressive small-log mill. The growing number of riderless carriages in small-log operations is convincing argument that a sawyer pushing buttons is as efficient as a sawyer signalling the next set-out to a setterman, and what is more it is proving far more economical over the long pull. Even the big-log mill is now on the verge of the riderless carriage.

Remote control of a carriage in modern sawmilling implies in addition to the setworks, control of automatic dogs, flippers, and tapers. Maintenance problems on the remote-control carriage are becoming less pronounced as industry experience with them broadens.

Like the riderless carriage, automatic log decks are a reality in the small-log mill and obtainable at a cost within the reach of any progressive operator. In many installations, the automatic deck and riderless carriage are both controlled by the sawyer and the efficiency of this setup leaves little basis for debate.

The carriage-type mill, to justify its existence in the purely small-log operation, is pledged to the maximum recovery of any grade contained in the log. Within the last few years, the development of the modified Hill-type turner with roller chain and teeth has given the small-log operator the practical mechanical turner for "inching" logs around against the carriage knees to bring up the best cutting face for sawing. Again, the increasing use of mechanical turning devices is becoming increasingly evident.

The merits of taper sawing small logs is another subject that is rapidly losing its popularity as a subject for debate among lumbermen and again, in keeping with the modern trend, automatic taper-setting devices are being incorporated extensively into carriage knees. Two general types of automatic taper-setting devices have been developed for the small-log carriages. In the first type, the knee including its dogs moves forward or back with respect to the other knees, and in the second, a separate plate is attached to the side of the knee and moves out without the dog. Again, either type can be remotely controlled by the sawyer.

Although a subject in itself, much research in recent years has been devoted to the subject of dogging logs and cants on the carriage. A wide range of highly acceptable dogs have been developed to meet the needs of the small-log operation. Most of the dogs produced by reputable manufacturers give fast, accurate dogging with a minimum of lumber defacement.

Small Band Mills

The riderless carriages and automatic log decks function to maximum advantage when used in conjunction with the small band mill. Less than five years ago, it was difficult to find a small-log mill fitted with a band headrig. Millmen cited the cost as the factor prohibiting its use, but today it is not uncommon to find many 20 to 30 M feet per day mills operating with band headrigs ranging in size from 54 to 72 inches. High stumpage prices and limited timber supplies favor the band mill installation for this size operation in today's economy as it can be rather conclusively shown that a band mill can pay for itself in a period of less than two years. The extra earnings from cutting more lumber with a reduced volume of stumpage appeals to many small mill owners in second-growth areas where the log-supply problem is acute.

The small automatic band mill is also proving to be an efficient scavenger mill as an accessory to a large-log mill. In addition to sawing the small logs efficiently, the band mill does an excellent job on broken pieces and chunks that are accumulated in salvage. Operators who have adopted this application of the small band mill point to its flexibility as a major selling point. The high productivity of the small band mill, the steady, uniform rate of lumber flow, and the low manpower requirements are definite assets in its favor.

The Skrag Mill

The role of the Skrag-type mill in processing small softwoods is difficult to evaluate because mill-study data on its efficiency and grade recovery are lacking. A Skrag mill is simply a breakdown unit in which the round log is forced between parallel pairs of movable circular saws which accomplish the removal of slabs from both sides of the log simultaneously while cutting out a four- or six-inch cant from the center portion of the log. The most popular use of the Skrag mill is for breaking down small, low-grade, eight-foot logs in the stud mill operation. The number of Skrag mills in operation at the present is rather limited.

In summary, the new developments in the milling of softwood logs are largely brought about by industry application of the gifts of modern technology. The sawmill industry will never be without problems but promise of faster, more accurate and more automatic equipment is definitely in the offing at a price that the industry can pay.

Discussion

J. Mueller (J. Neils Lbr. Co.): What is the average cut in a riderless carriage small band mill?

Mr. Thomas: They range from 20 to 35,000 in the Puget Sound Basin. The average is probably higher in other sections.

Jack Preiffer (Oregon Forest Products Lab): It may be of interest to know that in a recent mill study in Oregon, one scrag mill was cutting nearly 3,000 8-foot logs in an 8-hour day.

M. H. Mater (Mater Engineering): In a small band mill with a riderless carriage, the limiting production factor is size of the band mill and size of the log, not the riderless carriage. In Douglas-fir, mills cutting 100,000 board feet per shift are using riderless carriages; in ponderosa pine, mills cutting 60–70,000 per shift on the headrig are using riderless carriages.

F. C. Simmons (Northeastern For. Exp. Sta.): We're beginning to see more sash gang mills cutting their logs on two sides with a conventional or twin circular mill first and then putting logs through the gang mill as cants. The advantages are that you can get grade from all sides, better feeding efficiency (less heaving and twisting), and less edger work. On small logs, 3 or 4 cants can be put on top of each other and fed through the gang at once.

G. S. J. Bowell (MacMillan & Bloedel, Ltd.): We are sawing small logs on two sides only, leaving a center cant. We've developed a slabber and cut logs 32 feet long and 8 to 20 inches in diameter, making one pass only. Production is 40,000 feet per shift. We've been able to build up the sawmill flow when needed. After the 2-saw slabber, the cants go to a Wickes gang and the slabs to a horizontal resaw.

Surfacing of the Western Pines and Associated Woods [1]

HALL A. LOGAN and DEAN C. BRICE[2]

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Surfacing is one of the critical processes in the manufacture of lumber and therefore offers an excellent opportunity to develop and maintain a high quality of finished product. This paper presents the results of a study of the variables in planer operation, describes their effect on surface quality, and provides a guide to improved production with minimum degrade.

IN THE MANUFACTURE OF LUMBER, there are many stages wherein the quality of the finished product can be controlled. Three of the most critical are the processes of sawing, seasoning, and surfacing. Each of these stages of manufacture produces a component quality that is incorporated into the finished product. If at any time one of these processes fails to produce utmost quality, degrade occurs with a loss in surface appearance, monetary value, or both. But, if more than one of these processes fail, such a combination of conditions can cause a more severe loss.

Monetary loss due to planing degrade is of prime importance to each mill operation. Of equal importance, but often overlooked, is surface quality. Being unable to attach a value to surface quality, it is difficult to stress its importance. However, with the grading rules based upon an appearance grade, it can be readily understood that with good surfacing the other natural defects can be of increased intensity.

With an understanding of the factors affecting surface quality, greater benefits can be attained in the form of improved production at the surfacing machine with a minimum of degrade loss. Therefore, it is the purpose of this report to discuss the variables that exist in the operation of a planer, and the effect each one has upon surface quality.

The object of this research was to study planer operation systematically, and at the same time to record the machining characteristics of the Western Pines and associated woods. In conducting this work, the variables related to machine design and operation studied were feed speed, knife angle, and knife heel. Moisture content and rough material thickness and width remained constant. The controlling of rough lumber dimensions had the effect of controlling depth of cut.

In analyzing the finished surfaces of the test material, two factors were considered: surface quality and degrade. In the surfacing of lumber, it is possible to produce many degrees of quality, while not causing any appreciable loss in degrade. However, if careful attention is not given to the planing operation, a serious loss in degrade may result.

Test Machine

All of the testing was conducted with one machine in order to eliminate any differences that might exist among machines. This procedure should not be misinterpreted, as there is no reason to believe that the results produced by this machine would not be applicable to other machines.

Various feed speeds were obtained by using different size pulleys on the feed motor. The feed speeds investigated, and the resulting cuts per inch and inches per cut were:

Feed Speed (Feet per Minute)	Cuts per Inch*	Inches per Cut*
305	11.48	.087
350	10.00	.100
420	8.33	.120

*Calculated when under load at 3,500 RPM as follows:

$$\text{Cuts per inch} = \frac{kn}{12f}$$

where:
k = number of knives in the cylinder
n = spindle speed (RPM)
f = feed speed (feet per minute)
Inches per cut were determined by using the reciprocal of this equation.

Test Material

Selection of material was one of the most important phases of this work. As there are ten species of Western pines and associated woods, it was a major task to assemble sizable quantities of each species at one mill location. As it was, only eight of the ten species could be secured for testing. These were: Idaho white pine, ponderosa pine, Douglas-fir, Engelmann spruce, larch, lodgepole pine, western red cedar, and white fir. All material came from the vicinity of the Clearwater National Forest in Idaho, with the exception of the spruce, which was cut in the Couer d'Alene, Idaho area and the lodgepole pine from the Cascade, Idaho region.

The test material had to meet three requirements before it was accepted for testing:

(1) Grades used: Common grades of lumber were used, since they are the most difficult to machine. Mill-run yield of grade was used. The percentage of grade was checked against that which has been determined by the Western Pine Association as average for the pine region, and it was found to be nearly the same. Only four grades of common were used, No. 1 thru No. 4. Even with careful grading, some Select and No. 5 grades were in each test run; however, the quantity was small enough so that it did not affect the final results.

(2) Uniform size material: Size was important because the material was surfaced only once and this was the only method of controlling the depth of cut. Although only a visual check was used, the material was given careful attention so that the accepted pieces were of a uniform thickness and width.

(3) Moisture content: This was undoubtedly the most important requirement. It has been determined by previous research conducted by the Laboratory that moisture content controls the degrade loss which occurs when lumber is surfaced. From this previous work, the moisture content standards were established for this study. The range of moisture contents used and determined by moisture meter were

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[1] Presented at Session X, Machining, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

[2] Authored by Hall A. Logan and based on research he conducted while Industrial Engineer at Western Pine Assoc. Edited and presented by Dean C. Brice.

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10 to 16 per cent, with the central tendency of the distribution at 12 per cent.

The material was obtained from the sawmill green and then dried in kiln loads of approximately 50 M board feet of material. The schedules used in drying were not necessarily production schedules, but those that would produce uniform moisture contents. After seasoning, the material was graded in the rough, checked for size, and then stacked in test unit packages and placed in storage. The moisture content was again checked after each test unit had been machined, and did not vary from that which existed previous to storage.

Over 400,000 board feet of material were thus assembled and seasoned. From this quantity, nearly 275,000 board feet were used in these tests.

Test Procedure

The same procedure was used for all tests with changes being made in feed speed, knife angle, and knife heel to obtain a range in results. Each species of material had the same location in the order of machining. The planer machined four finished surfaces; however, only the two wide faces were evaluated. The side heads producing the two narrow faces remained unchanged for all tests. With this being a two-face test, it was necessary that the machine be carefully adjusted so that an equal amount of material would be removed from each face. Unequal surfacing would have produced lumber with one grading face, and this condition would not have given reliable results. Careful attention was given to machine operation in an effort to attain a uniformly machined product.

The test runs were grouped so as to machine the greatest amount of material and at the same time not have large quantities on hand to create storage and laborious grading problems. The process of grading was performed immediately after each test run. Usually the material was run in quantities of 20,000 board feet, representing four species or one-half the material of a given test run. This quantity required about 2 hours to machine and approximately 2½ days to grade. When investigating knife angle, it was desirable to run the eight species through the machine at one time because of the intricate setting of the knives. Thus, storage area for the finished material and fatigue associated with the intensive grading governed the size of test runs.

The Western Pine Association Standard Grading Rules, effective January 1, 1953, were applied to the grading test material. When grading the finished surfaces, enough time was devoted to each piece to establish its grade, to determine if any degrade had taken place, and to assign visually a degree of surface quality. Although tedious, at no time was the grading slighted in any manner. Pieces of material that were in doubt were given additional time for study. Every effort was made to maintain a uniform grade and a uniform evaluation of surface quality.

In grading the material and in evaluating the surface quality, it was necessary to assign values to the various types of defects. The standard grading rules were applied to all grading; however, degrade was recorded for those defects that are assignable only to planer operation. One exception to this procedure was the disregard for roller split. This is a separate problem and will be studied later.

The defects that were considered and evaluated are described by the American Lumber Standard for Softwood Lumber 16–53, as being:

Chipped grain—Area where the surface is chipped or broken out in very short particles below the line of cut. Not classed as torn grain and, as usually found, is not considered unless in excess of 25 per cent of the surface area.

Raised grain—Roughened condition of the surface of dressed lumber in which the hard summerwood is raised above the softer springwood, but not torn loose from it.

Torn grain—

Slight: Not over 1/32″ deep.
Medium: Over 1/32″, but not over 1/16″ deep.
Heavy: Over 1/16″, but not over 1/8″ deep.
Deep: Over 1/8″ deep.

The defects which were not defined by the standard and which occur in wood machining are fuzzy grain and chip marks. Fuzzy grain most generally appears on the surface of the material in the form of surface fibers that have not been cleanly severed. Chip marks are actually indentations in the surface and are caused by chips being forced into the surface by the knife edge.

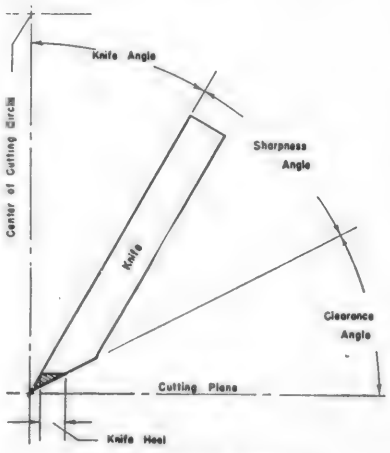

Fig. 1.—Knife detail.

In this study, chipped grain and torn grain were considered the same, because of the difficulty in differentiating between the two. Knots were grouped into two categories: red and black, and these were classified either as partially broken or as completely broken. Torn grain, raised grain, and fuzzy grain were classified into three degrees of intensity: slight, medium, and heavy.

Variables

Material moisture content, thickness, and grade, together with knife sharpness, were closely controlled. Other variables which were also controlled and varied one at a time were (1) knife angle, (2) knife heel, and (3) feed speed. As each variable was studied, the other two variables were maintained at their respective minimums. This procedure did not give results for the many combinations of variables.

Knife angle is defined as that angle which is formed between the face of the knife and a line drawn through the center of the cylinder and intersecting the cutting circle at the point of contact of the unjointed knife. This is illustrated in Fig. 1.

The knife angles studied were 20°, 25° and 30°. The 20° angle was that which was machined in the cylinder and was therefore readily available. To obtain the 25° and 30° angles, it was necessary to have auxiliary angles ground in the face of the knives.

Although it would not prove satisfactory to convert a planer cylinder's cutting angle in this manner, the technique was entirely reliable in altering the cutting angle for experimental work.

Knife heel is that area of the knife edge that is increased with continued jointing. Initial jointing is for the purpose of bringing all the cutting edges into the same cutting circle. Further jointing provides a means of sharpening the knives without removing them from the cylinder.

The heels studied were minimum and maximum. Their width was measured with a calibrated microscope. Minimum heel is that heel which is created when all cutting edges are jointed into the same cutting circle. There was a slight range of widths with the average falling at .012″. The maximum heel also had a range with

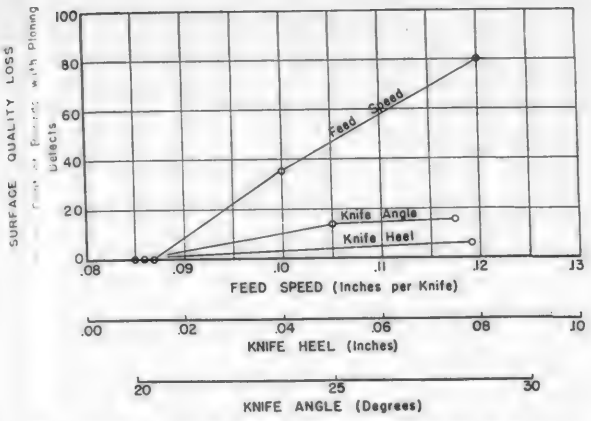

Fig. 2.—The effect of the machining variables on the surface quality of Idaho white pine.

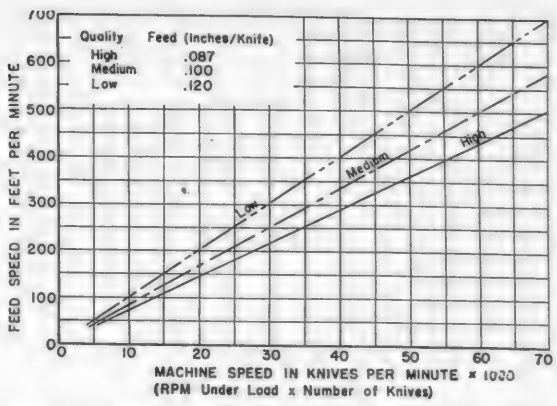

Fig. 3.—Relation between machine speed and feed speed at various levels of surface quality.

the average being around .088″. With the maximum heel at .088″, the width then represented a sizable portion of the knife since the overall thickness was only .156″.

Feed speed, in terms of inches per knife, is related to the number of knives in the cylinder, revolutions per minute of the cylinder, and feed speed of the material in feet per minute. Three feed speeds were studied: .087, .100, and .120 inch per cut. This range gave qualities of finish from high to very low.

Discussion

Many factors associated with machining of lumber can contribute to varying degrees of surface quality and also monetary loss due to material degrade. Some of these factors are inherent in the material, while others exist in the machine itself.

The characteristics in wood which cause difficulty in machining are knots with the diagonal grain and clear wood having diagonal grain. With present-day methods of manufacturing, nothing can be done to eliminate these characteristics which exist in wood. However, moisture content can be controlled to give varying degrees of finished surface.

Variables in a planer offer the greatest opportunity to improve and maintain a high quality of finished product. Modern high-speed planers, therefore, require trained operators. Machinery operated by inexperienced personnel can at times produce medium to low quality millwork. Too, maintenance given the machine can be considered a variable in producing surface qualities. Defective machine bearings are often the cause of poor machined surfaces. Alignment and adjustment of the machine are also important factors. When any undue pressure is exerted on the material as it passes through a planer, damage to the finished surface will result. Since some species of softwoods are quite fragile, extensive damage can occur with improper machining methods.

Furthermore, the importance of knife sharpness should not be disregarded. Sharp knives do a good job of machining regardless of their angle, feed speed, or heel. Knife sharpness and knife heel are not the same. A knife with a slight heel can be dull, while at the same time a knife with a wide heel can be sharp. Frequent jointing with the resulting widening of the heel will continue to produce good surfaces with only a slight loss in degrade.

Knife angles have slight effect upon degrade loss; however, various degrees of surface quality can be produced with different knife angles. As the knife angle is changed, raised grain or torn grain appears in various degrees of intensity. Low knife angles, those approaching zero degrees, tend to cause raised grain due to the scraping action. Increasing the knife angle will eliminate the raised grain, but the torn grain will increase in intensity due to the lifting action of the knives. Low knife angles will cause the surface to have a fuzzy appearance, because the cutting edges do not cleanly sever the wood fibers.

Of all the variables studied, feed speed caused the greatest amount of loss in surface quality and in monetary value due to material degrade. Since material thickness was controlled within relatively close limits, it had little effect upon chip load. Variations in thickness will give different length of chips, while increasing the feed speed will increase chip thickness. It is the increase in feed speed and resulting increase in chip thickness that causes the greatest loss in surface quality. Thick chips are resistant to bending, and therefore, the material shears along the grain and causes the fibers to break off below the finished surface. Thus, high feed speeds used in machining coarse grained material can cause severe damage.

One fact that should not be overlooked is that the common grades of lumber present a machining operation in two grain directions: longitudinally in the straight grain and transversally in the knot areas. Consequently, reasonable feed speeds in machining common grades of lumber are required to produce surfaces with relatively few broken knots or areas of torn grain.

The evaluation of surface quality, although difficult, should not be disregarded. Regardless of grade, the material should have a good surface quality since the end use of any particular grade is usually unknown at the time of manufacture. Low grades of lumber, therefore, should not necessarily have correspondingly low qualities of surface.

Fig. 2 graphically presents the magnitude of the effect of each variable on the surface quality of one of the species studied. Idaho white pine is one of the easiest species of softwoods to machine. Feed speed caused the greatest amount of surface quality deterioration. Torn grain, one of the most serious defects in machining this species, can be controlled by limiting the feed speed to .087″ per knife. Knife heel caused only slight damage to the surface. Unsevered surface fibers, which were not of the intensity to be classed as fuzzy grain, detracted from the appearance of the material. An increase in knife angle from 20° to 30° severed the surface fibers more cleanly, and thereby made a much smoother surface with only a slight increase in torn grain around the knots.

Application of Results

Feed speed, in terms of inches per knife, is the most critical variable in planer operation. With all variables controlled, feed speed can cause the greatest deterioration of surface quality and degrade loss. Since feed speed is related to production, it should be understood how it can be used to the fullest extent so that maximum produc-

Table 1.—RECOMMENDATIONS FOR OPTIMUM PLANER OPERATION

Species	Feed Speed in Inches per Knife	Knife Heel	Knife Angle		
			First Choice	Second Choice	Third Choice
Idaho White Pine	.087	Min.	20°	25°	30°
Ponderosa Pine	.087	Min.	20°	30°	25°
Douglas Fir	.087	Min.	25°	30°	20°
Engelmann Spruce	.087	Min.	25°	20°	30°
Larch	.087	Min.	30°	20°	25°
Lodgepole Pine	.087	Min.	25°	30°	20°
Western Red Cedar	.087	Min.	20°	25°	30°
White Fir	.087	Min.	30°	25°	20°

Table 2.—SURFACE DEFECTS AND THEIR CAUSES

		Torn Grain	Raised Grain	Fuzzy Grain	Broken Knots
Feed Speed	Low		x	x	
	High	x			x
Depth of Cut	Small		x	x	
	Large	x			x
Knife Angle	Small		x	x	
	Large	x			
Dull Knives			x	x	x
Wide Knife Heel			x	x	x
Moisture Content of Material	Low	x			x
	High		x	x	
Heart Side of Lumber			x		
Cross Grain Lumber		x			
Chip Breaker Too Far From Knives		x			
Excessive Pressure From Feed Rolls, Pressure Bars, and Knives			x		

tion can be attained along with a high quality of surface and no resulting degrade loss.

The relationship of feed speed and surface quality is presented graphically in Fig. 3.

The various points described in detail in the Discussion section of this paper are summarized in Tables 1 and 2. These two tables are self-explanatory and are presented in this form for convenient reference.

Discussion

C. W. Jones (Stetson-Ross Machine Co.): High feed speeds in themselves do not cause defects, do they? By increasing the number of knives in the head, presumably a higher feed rate could be achieved without increasing the percentage of machining defects?

Mr. Brice: Feed speed depends on how you define it. We are discussing feet of material per knife, leaving open any changes of spindle speed. You can use any combination of variables desired. In tests up to 20 knife marks per inch, you get a leveling off of surface quality. The curve of surface quality starts breaking after 12 knife marks per inch and flattens out at 16 knife marks per inch.

George Dickson (Stetson-Ross Machine Co.): Knife marks per inch do affect the finish you get. The diameter of the head also has an effect. With an 8-inch cutting circle you get a longer, more sweeping cut than with a 5-inch cutting circle, for instance. There would be some tendency to tear out the grain at high speeds when small diameter heads are used. You can run an 11 inch cutting circle head and get much better work than a 5 inch will give, even though the number of knife cuts to the inch is the same.

Venetian blind slats are most critical for finish purposes. Experience shows that about 17–22 cuts to the inch are necessary to pass rigid inspection. This would seem to bear out your statement that beyond 20 cuts to the inch, little improvement in finish results.

W. J. Tomford (Stark Lbr. Co.): Mention has been made that belt sanding would be used as a final operation for a real smooth finish. I understand the European practice is to use a scraper to get a super-fine finish. Perhaps this could be adapted here where necessary.

L. A. Patronsky (Wabash Screen Door Co.): They have a scraper behind the knife to take off the humps.

John Reno (Pacific Lbr. Co.): A 10-inch cut doesn't necessarily mean 10 knife marks per inch, does it?

Peter Koch (Michigan State College): Yes, you always get 10 knife marks per inch with a tenth-inch feed per knife contact.

Saving Lumber Through Blanking with the Two-Way Thicknessing Planer[1]

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Two-way thicknessing planer has been developed which thicknesses boards twice—first from the back, then the face. This planer enables sawing to closer tolerances than ordinary practice allows, thereby increasing yield from the log. Advantages and disadvantages of blanking are discussed, two-way planer is compared with conventional surfacers, and potential ways of saving lumber are explained.

Introduction

LUMBERMEN HAVE LONG REALIZED the advantages of blanking lumber. Blanking is the process of pre-planing lumber before it is finish-planed. This term is generally applied to stock which is surfaced top and bottom, but in some cases the edges may be blanked also. This paper deals only with blanking the top and bottom, rather than 4-side blanking.

Blanked lumber can be classified in two categories:

1. Shop lumber for sales to cabinet shops, furniture factories, or other types of re-manufacturers. This type of stock is planed only once at the planing mill, principally so that the lumber may be sized and graded before it is sold.

2. Lumber retained at the planing mill for re-running into the commonly recognized lumber patterns, flooring and mouldings. Lumber in this category naturally has to be planed twice if the blanking operation is carried out.

Advantages of Blanking Lumber

In the first place, the running of lumber through a double surfacer brings it to a uniform thickness.

Second, any excess stock is removed in the blanking process, leaving to the matcher or moulder only the jobs of making the final finishing cut and machining the pattern. When running blanked stock, the matcher or moulder can be set for greater accuracy than is the case when rough lumber is run. The pressure shoes, guides, and chipbreakers do not have to be set to take into account wide variations in size. The cutterheads are not subject to the shock loads imposed by unevenly sawn lumber. The result is inevitably a finer finishing job.

Third, and most important, blanked lumber can be accurately graded and sorted to determine its best and most profitable end use. Also, much blanked lumber can be upgraded by selective ripping and trimming prior to its final finishing. Great savings and profit opportunities are available in this procedure, if it is correctly done.

Why Blanking Has Not Been Universally Adopted

At first glance, it would seem desirable for every mill to blank all lumber if these advantages can be realized. Why then, is so much lumber planed from rough lumber to finished lumber without taking advantage of the upgrading and other advantages which blanking offers? The first and most obvious reason is the cost of additional planing, trimming, and handling facilities, plus the extra labor cost to do blanking. Certainly, this is no small item. However, the opportunities for upgrading may very well offset this cost in a relatively short period of time. The extent to which this is true in any particular mill can only be determined by controlled experimentation.

Second and most important, a majority of planers in use today are constructed so that every board which passes through them is reduced in thickness, because the bottom cylinder takes a fixed, pre-determined cut from each board without regard to its thickness. Thus, the lumber is made thinner when it goes through the blanking planer and then still thinner when it runs through the finishing planer. For this reason, boards to be blanked must necessarily be sawn thicker than the stock to be planed to its final size in a single planing operation from the rough board. Extra thickness must be allowed by the sawyer if the board is to be twice reduced in thickness in the planing operations. This obviously reduces the yield from the log and will substantially offset the advantages gained through blanking.

Means for Conserving Lumber

No miracle has been discovered by which the machinery or labor required to blank lumber can be eliminated. However, there is planing equipment available which eliminates the necessity of sawing oversize and which positively cannot make a board which is sawn scant any thinner than it already is. It is easy to visualize the lumber that may be sawed by such a machine.

The machine which accomplishes this is known as the two-way thicknessing blanker or pre-surfacer, shown in Fig. 1. The two-way thicknessing planer is so-called because it thicknesses each board twice, first from the bottom and then from the top.[2]

[2] U. S. Patent #2,102,186, Canadian Patent #378,123, other patents pending.

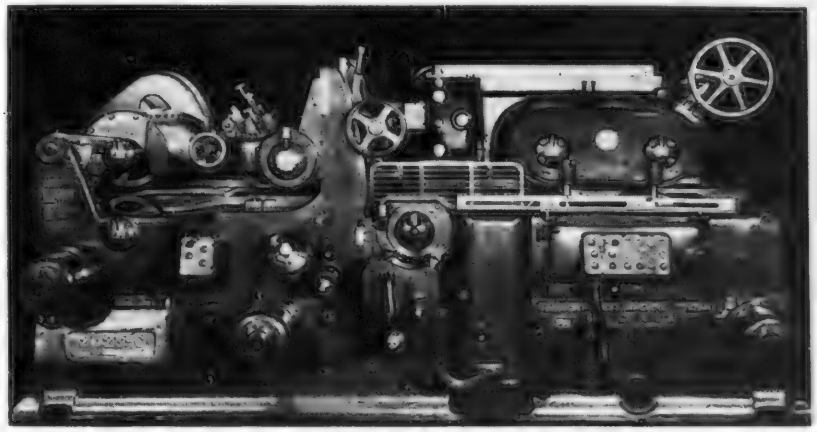

Fig. 1.—Stetson-Ross two-way thicknessing pre-surfacer or blanker. Note "holding-up" mechanism between infeed rolls and bottom head. This holds the stock against the top platen as it passes over the bottom head. The heads are equipped with 10, 12, or 14 knives, depending upon the job to be done.

[1] Presented at Session X, Machining, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

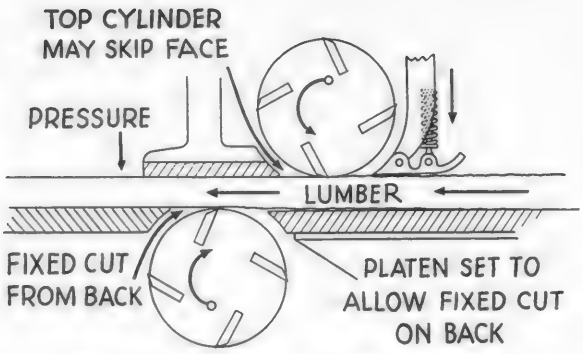

Fig. 2.—Conventional planer head arrangement.

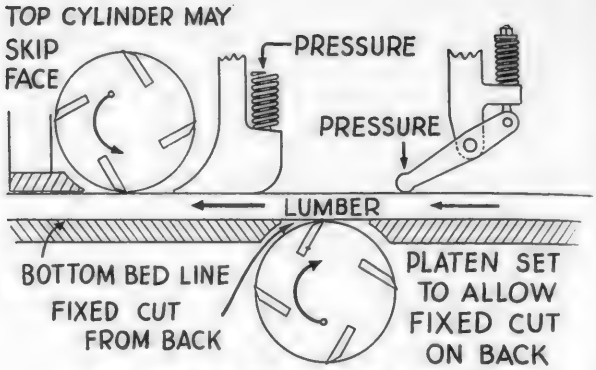

Fig. 3.—Another possible cylinder arrangement on conventional type machine.

The advantages of the double thicknessing machine are best illustrated by comparing it to the more conventional types of planer head arrangements.

Comparison of Cutterhead Arrangements

Most high speed planers today are made with a cutterhead arrangement as in Fig. 2, where the top head cuts first, finishing the face and hogging off the excess thickness. The bottom head then takes a cut from the bottom of each board that passes through the machine—even though that board may already be too thin.

Fig. 3 illustrates another head arrangement used on some planers. Here the bottom head cuts first, but it also takes a pre-determined cut from the bottom of each board regardless of the thickness of the board. This cutterhead arrangement also has the disadvantage that the holddown means over the bottom head is spring loaded and may flutter when feeding irregularly sawn stock at the higher rates of feed. This is, of course, reflected in an uneven finish.

Fig. 4 shows the cutterhead arrangement used on the two-way thicknessing machine:

1. Note that the bottom head cuts first; however, the board is held against a top non-yielding platen by a chipbreaker mechanism ahead of the bottom cylinder. Thus, all excess thickness is hogged off the board by the bottom head. If the board is too thin, the bottom head will skip.

2. As the board leaves the bottom head it is slightly flexed and held down by the top cylinder chipbreaker shoes before the top cut is made.

3. The top head takes the finishing cut for which it is set.

4. From this it becomes obvious that the following three conditions may prevail:

A) The finished board may come out of the machine planed on both top and bottom.

B) The board may be finished on the face but skipped on the back. It is important to note that a finished face is prima facie evidence that the board is fully up to thickness because the top head planes last and is a thicknessing head, set to finish stock to the desired thickness. Even though skips appear on the back of a board, accurate gauging of the board will reveal that any time the face has been planed, that board is full thickness. This is fundamental and is one of the most important facts to remember about two-way thicknessing.

C) The board may come through the machine skipped on both face and back, if it is too thin to dress out to the desired thickness. In this case, the thin board has not been made needlessly thinner and it may be salvaged for some other purpose. The two-way thicknessing blanker is the only double surfacer which automatically passes the extra thin board through without planing it. Thus, the planer acts as an accurate sorter for thin stock. At the same time, it yields the maximum amount of full thickness stock.

5. Note also that stock is flexed slightly from the upper bed plate to lower bed plate by means of the spring pressure of the top cylinder chipbreaker. Thus stock is continuously and in an endless stream being transferred from upper to lower bedline while under this longitudinal flexing tension. This not only prevents flutter of stock and eliminates snipping of ends, but, also tends to improve surface smoothness.

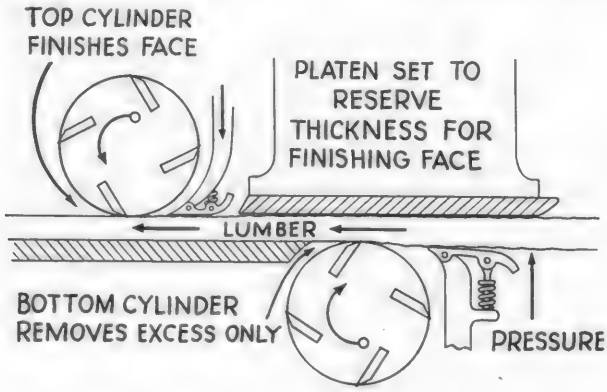

Fig. 4.—Two-way thicknessing planer head arrangement.

Construction of the Two-Way Thicknessing Planer

The construction of the two-way thicknessing pre-surfacer is radically different from ordinary machines, and is substantially more expensive to build. The top infeed rolls are set at will to the desired lumber thickness and are locked solidly in that position. The bottom infeed rolls yield under spring pressure to allow for stock thickness variation—much the same as the top rolls do on orthodox types of planers. For this reason, the machine has sometimes been called "the upside-down machine".

It will also be seen that a solid, non-yielding, but adjustable top platen is provided above the bottom head. Also, there is a bottom bed plate ahead of the bottom cylinder.

A substantial "holding up" mechanism is built in ahead of the bottom cylinder to hold the stock firmly against the solid top platen. This holding up mechanism also incorporates sectional yielding anti-snip chipbreakers. An additional set of sectional

yielding chipbreakers is also built ahead of the top cylinder.

Built-in hoisting motors are provided for quickly setting the infeed rolls, top platen, top cylinder, and top outfeed roll. This aids in rapid setups and in clearing out breakups. The result is more actual running time.

The feedworks of the machine operates in an oil bath much the same as the crank case of an automobile. There are, of course, other mechanical features of the machine not directly related to the two-way thicknessing principle; and thus beyond the scope of this paper.

By comparison, it will be readily seen that blankers with cutterhead arrangements as in Figs. 2 and 3 will make many blanked pieces too thin to dress out to full thickness in the final planing operation. The only solution, if these types of planers are used, is to saw a little heavier. This, of course, reduces log yield and will partially or totally offset the advantages to be gained by the blanking or pre-surfacing of lumber.

The amount of saving which can be realized by the use of the two-way thicknessing planer can be determined only after a study of sawing practices in any particular plant.

In the regular process of sawing lumber, it is certain that some boards will be sawn thinner than others. Naturally, the sawmill sawyer is striving to produce a certain thickness, but while trying to do this and not obtain too much thin stock, the sawyer is certain to produce some thin boards. This is as it should be. A certain amount of thin stock should accrue. Unless a lumber manufacturer is producing approximately 5 per cent thin stock, he should beware of the fact that a great deal of lumber is being lost through sawing too thick. It can readily be seen that if the sawing is 1/16″ too thick, one 1″ board is lost out of every 16. If it is 1/32″ too thick, one 1″ board is lost out of every 32.

From this it is obvious that the greatest opportunity for saving through the use of the two-way thicknessing blanker is to follow the policy of sawing much more closely than ordinary practice allows, and thereby get a greater yield from the log.

Even though no changes in sawing practice are made, there is still substantial saving possible through reducing the number of thins. The exact percentage of saving will vary with the plant, stock being run and other variables. However, the number of thins resulting in one plant studied were reduced approximately 90 per cent after two-way thicknessing planers were put into operation.

Infeed end of Stetson–Ross 6–12–CH6 presurfacer. Top divided rolls grip edges of board, thus avoiding pressure on center of cupped lumber. Result is substantial reduction in loss from splitting.

Summary

These conclusions are indicated:

1. The blanking or pre-surfacing of lumber prior to final finish planing is desirable so that the lumber may be sorted and trimmed to yield maximum utility and value.

2. The two-way thicknessing blanker should be used in pre-surfacing operations because:

A) It will not make the thin board thinner, and cause degrades because of thinness.

B) Any skips on the face of the blanked lumber will automatically tell the grader which pieces do not have adequate thickness to dress out in the final finishing operation.

C) The two-way thicknessing machine will enable the mill to saw closer to the line and actually increase the yield from the log.

Discussion

John Reno (Pacific Lumber Co.): If a mill does accurate sawing, would this machine still be a good investment?

Mr. Jones: Yes, especially if you want to blank your lumber. Any blanking not on the two-way thicknessing principle would automatically remove a fixed cut from the back even though that piece were already slightly scant. It would still be necessary to saw thick enough to allow two complete cuts from each surface, if you want to blank and finish plane. In so doing, you would be certain to saw some pieces too thick even though careful sawing is done. Two-way thicknessing permits you to saw closer to the line without loss.

R. D. Short (Timber Structures): Do you get a flexing action on such thicknesses as 1⅝″ maple or oak?

Mr. Jones: This machine is suitable for stock up to 4″ thick. Machines using this principle successfully produce hardwood flooring in various sizes. The amount of flexing is not great, and I can see no reason why it would not function very well on maple or oak 1⅝″ thick.

L. A. Patronsky (Wabash Screen Door Co.): How wide is the machine?

Mr. Jones: The model shown here is 20″ wide, although it is built in various widths from 9″ to 25″. The machine shown has sectional yielding rollers on the bottom.

L. A. Patronsky: What about surfacing cupped lumber?

George Dickson (Stetson-Ross Machine Co.): The surfacer discussed by Mr. Jones was not built for cup blanking, but it could be so built. In planing cupped lumber, particularly in 4/4 pine, a great deal of loss results from splitting, as the lumber goes through the planer rolls. A special machine is built to solve this problem. See Fig. 5. Note that the top infeed rolls are built in two sections. The outer section adjusts to the desired stock width. Thus the top rolls hold only the edges of the boards and do not exert pressure in the middle of the cup. Light weight sectional chipbreaker shoes ahead of the top cylinder and a flexible pressure bar over the bottom cylinder are used. The first head planes off the lower corners; the second head planes off the top of the cup.

This cup blanker attaches directly to the infeed end of the planer matcher. Several companies have reported roll split losses decreased 80–90% when this type of machine is used.

J. D. Lewis (Cascade Lumber Co.): Is this machine only used for cupped lumber?

Mr. Dickson: No, it can be used for either straight or cupped lumber.

An Analysis of Chip Formation in Wood Machining[1,2]

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This preliminary report on fundamental machining research considers the photographic analysis of chip formation. Basic types of chip formation and the associated surface characteristics are identified. The influences of various factors which control chip formation are discussed.

Historical Review

ADVANCES IN WOODWORKING MACHINERY during the last few decades have been important in helping wood-using industries meet the demands of quality at low cost. It is significant, however, that basic concepts of wood machining have received little attention; our progress has been limited primarily to accelerating old processes. With few exceptions, there has been no appreciable advance in the fundamental technology of machining.

In attempting to secure sound information on the cutting of wood it quickly becomes apparent that our present lack of fundamental knowledge precludes the possibility of obtaining either empirical or theoretical data that can be utilized to best advantage. In the course of machining studies at the University of Michigan's Wood Technology Laboratory the need for basic information has been clearly demonstrated. This prompted an initial study in 1951 of the cutting action of a shaper[3]. During this work, observation of the cutting process was made possible by use of microflash photography. With suitable triggering devices, a sequence of photographs was obtained showing the knife at any desired position during cutting. These photographs provided sharp, detailed images of chip formation, but due to equipment limitations sequences could not be made on a single chip.

Concurrent with the micro-flash experiments, a Fastax high-speed motion picture camera was used for machining research. This photographic equipment, which in a sense permits the magnification of time, provided a means of watching high-speed cutting at a rate that could be followed by the eye. Using a high magnification lens system, it was possible to observe the cutting process involved in the formation of a single chip. The films obtained proved extremely valuable as a research tool and as an instruction aid.

High-speed motion picture photography is an exceptionally revealing research technique and has found wide usage in all phases of motion analysis. It has, however, certain limitations when used for studies in wood machining. Not only is the equipment initially expensive, but great quantities of film are consumed. A one-hundred foot reel of film will usually record the happenings of only one second. The film image often lacks the detail desired because of peculiarities of the lens system. Further, the intense light sources usually required generate heat in such quantities that temperature and moisture control is difficult.

Method of Study

The value of motion picture photography for studies of cutting action was established by use of the Fastax camera. In attempts to improve this method of observation, it was assumed that if the cutting action could be slowed down sufficiently without altering chip formation, it would be possible to use standard motion picture methods and thus overcome the above-mentioned limitations of high-speed filming. In view of general agreement that speeds of 10,000 feet per minute are desired in wood cutting, the prospects of reducing velocities to a few inches per minute without seriously changing cutting characteristics were not encouraging. Nevertheless, the advantages to be gained by successful reduction of speed were great, and since planer studies showed no apparent change in cutting action between 5,000 and 10,000 feet per minute, an investigation of the relationship of cutting velocity and chip formation was thought to be justified.

Using the high-speed motion picture camera, chip formation at various velocities was studied. It was found that when all conditions were held constant except cutting velocity, the process of chip formation was virtually unaffected so long as a truly dynamic situation existed. As static conditions were approached, a gradual change in the cutting process was observed. This behavior is undoubtedly closely related to the changes in the strength properties of wood as the rate of loading is reduced from impact to static conditions.

Early in the study of the cutting process it became obvious that chip formation varied with changes in machining conditions. Further, it was observed that each chip removed during the rotary-cutting process was in fact a combination of chip forms. The study of these forms of chip removal during rotary-cutting was complicated by the continuously changing conditions during the separation of a single chip. The trochoidal path[4] of the cutting edge resulted in changes in such factors as cutting angle, clearance angle, instantaneous chip thickness, and relative grain angle Fig. 1. In order to obtain constant conditions it was necessary to consider a special case of rotary cutting where the cutting circle was of infinite diameter. This could then be treated as orthogonal cutting, where the cutting edge of the tool is perpendicular to the direction of relative motion of tool and workpiece and generates a plane surface parallel to the original work surface.

Thus simplified by the elimination of high cutting velocities and the complexity of rotary cutting, wood machining can be studied quite readily. Using orthogonal cutting with velocities of several inches per minute, a

[1] Presented at meeting of Great Lakes Section, FPRS, Dec. 1, 1954, in Grand Rapids, Mich.

[2] A preliminary report on doctoral research in wood technology conducted at U. of Michigan, Ann Arbor.

[3] Patronsky, L. A. 1953. Knife cutting problems. Jour. F.P.R.S. III (2): 15-19.

[4] Trochoid—the path described by a point a given distance from the center of a circle as the circle rolls along a fixed straight line.

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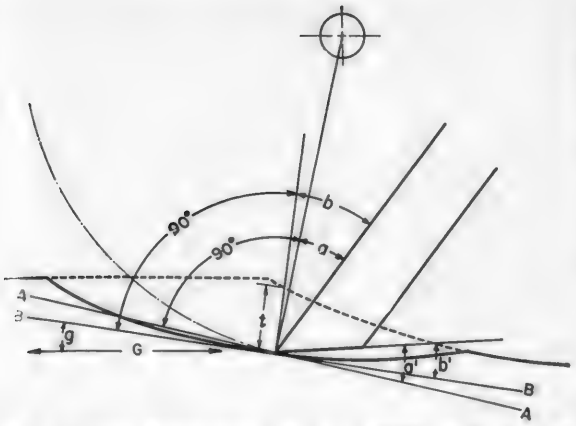

Fig. 1.—Cutting nomenclature. Line A-A, tangent to cutting circle through knife edge. Line B-B, tangent to actual cutting path through knife edge. Line G, grain direction of wood. Angles a and a', nominal cutting and nominal clearance angles, respectively. Angles b and b', actual cutting and actual clearance angles, respectively. Angle g, relative grain angle. t, instantaneous chip thickness.

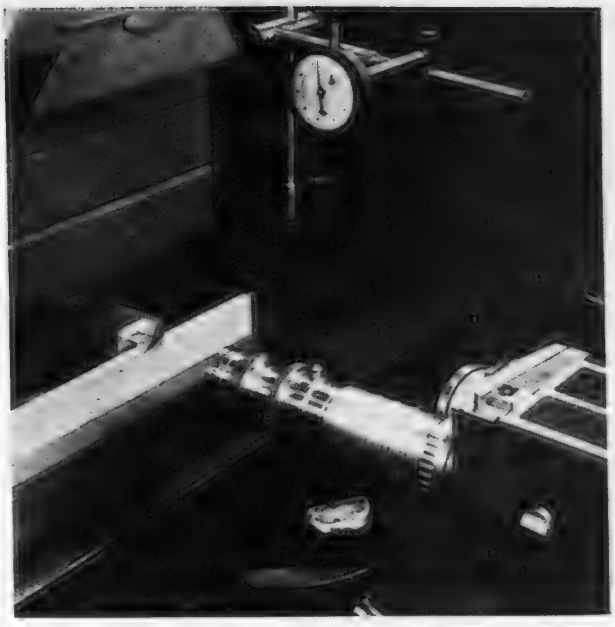

Fig. 3.—Close-up of milling machine showing dynamometer, work piece, and motion picture camera.

fundamental program of research was inaugurated to study factors influencing chip formation. A milling machine was adapted for this purpose, as shown in Figs. 2 and 3, with the work pieces held in a fixture on the table feeding against a stationary cutter. Interchangeable cutting bits, ground to the necessary specifications, were mounted in a specially designed dynamometer, calibrated to measure the forces on the cutting bit normal and parallel to the cutting path. These forces were continuously recorded by means of a double channel strain analyzer and oscillograph. Simultaneously, a 16 mm. motion picture camera equipped with a magnifying lens system made a photographic record of the process of chip formation. In this way it was possible to correlate the force patterns with the measurements and observations from the motion pictures.

The information obtained from this method of study has been valuable in understanding the fundamental concepts of wood machining. The following general discussion of chip type includes some of the early findings based on photographic analysis, and covers only the initial phases of the complete study. Reports on various other phases of this research will be made in the near future.

Chip Type

When cutting parallel to the grain, three basic types of formation can be distinguished. Type I chip is formed when cutting conditions are such that the wood splits ahead of the knife by cleavage until failure in bending as a cantilever beam occurs as seen in Fig. 4. Type II chip results when failure of the wood is due to diagonal shear as in Fig. 5. The Type III chip forms by compression and shearing of the wood as illustrated in Fig. 6. Certain

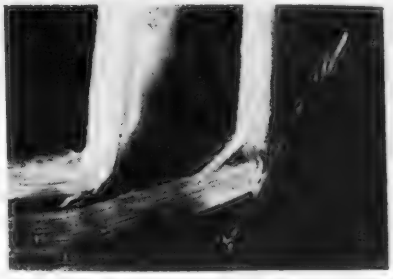

Fig. 4.—Photomicrograph of the Type I chip showing cleavage ahead of knife.

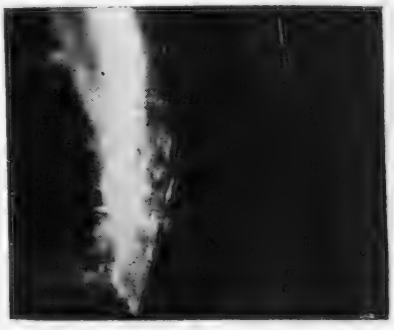

Fig. 5.—The Type II chip with wood failure continuous along a line running from the cutting edge to the wood surface.

Fig. 6.—Compression and shear failures ahead of the knife during formation of the Type III chip.

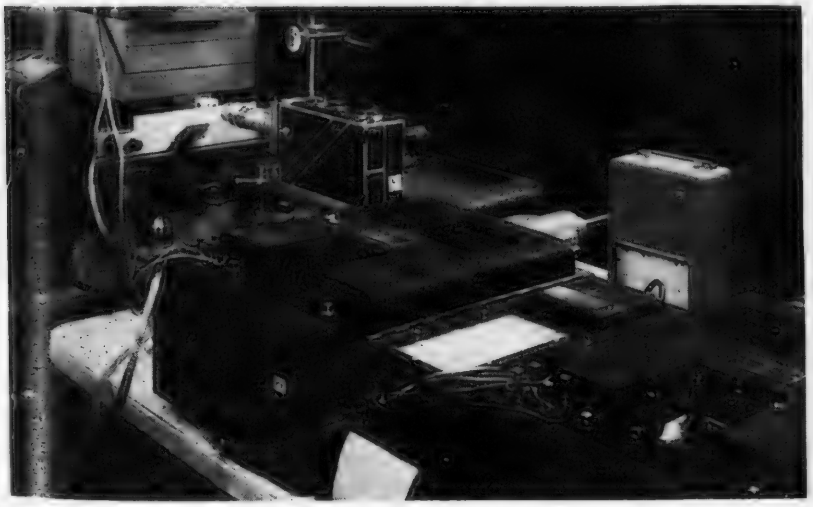

Fig. 2.—General view of equipment used for the study of chip formation in wood machining.

Fig. 7.—Formation of the Type I chip accompanied by a Type II chip when cutting with the grain.

Fig. 8.—The Type I chip when cutting against the grain showing splitting below the path of the cutting edge.

Fig. 9.—Photomicrograph of built-up edge caused by compacting of wood near cutting edge.

variations of these basic types of chip formation will occur when the cutting path is not exactly parallel to the grain of the wood, Figs. 7 and 8, or when friction on the face of the knife is excessive, Fig. 9.

When cutting perpendicularly to the grain on a side grain surface, as in slicing veneer, or when cutting end grain, limited investigation has shown that the types of chip formation also fall into the three general classifications given above. As would be expected, the character of the chip varies considerably due to the wide range in the wood properties with respect to grain direction.

The Type I chip provides the most efficient means of removing material and causes comparatively little wear on the cutting edge, but it can cause severe surface defects. This type of chip is most frequently found when large cutting angles are used and chip thicknesses are great. Under these conditions, the tool face exerts large forces in a direction normal to the plane of cutting, causing the wood ahead of the knife to fail in cleavage, after which the partially removed chip acts as a cantilever beam. As long as the strength of the beam exceeds the cleavage strength, the chip continues to split ahead of the knife, following the grain of the wood. When the beam reaches a critical length the bending moment becomes large enough to cause failure and the chip continues to slide up the face of the knife until the cutting edge again contacts the work and the cycle is repeated.

When the path of the cutting tool is parallel to the grain of the wood, or the cut is into sloping grain, the surface produced is of good quality, since a secondary chip of Type II is commonly formed and determines the quality, Fig. 7. If the cut is against the grain however, the splitting of the chip will frequently follow the grain below the plane of the cutting edge before bending failure occurs and the surface displays the defect ordinarily termed chipped grain, Fig. 8.

The Type II chip, Fig. 5, is most desirable from the standpoint of surface quality, although it probably causes considerable tool wear since the cutting edge is working at all times. This type of chip results when cutting conditions are such that the wood failure in the chip takes place in a line extending from the cutting edge to the work surface. The occurrence of this failure is dependent on a proper balance between wood properties, friction, chip thickness, and knife cutting angle, resulting in a diagonal shear plane. This represents rather careful control of the machining operation, since any unbalance of these factors will tend to change chip formation to another type. The chip is in the form of a smooth curl and is most easily obtained when moderate knife angles and keen cutting edges are used to remove thin chips.

The Type III chip is usually characteristic of cutting conditions where small knife angles are used or the friction between the knife face and the wood is relatively high. Under these conditions the face of the tool exerts large forces parallel to its direction of travel and very little in a direction normal to the surface being generated. This causes the wood ahead of the cutting edge to be stressed in compression and the resultant strain induces shearing stresses along a plane parallel to the direction of travel. Failure ultimately occurs, with the shear line determining the surface being generated. Since the surface is created not by the cutting edge in this instance, but by the wood ahead of the knife, the quality of the surface is understandably related to the compression and shear failures in that area. These failures produce surfaces exhibiting many crushed and loose-ended bundles of wood elements. The defect commonly called fuzzy grain results.

When very small or negative cutting angles are employed, or the friction on the face of the knife is excessive, the Type III chip may be varied somewhat by the presence of a built-up edge. In this case the wood material crushed during the formation of the chip is not free to slide up the face of the knife due to force distribution and is impinged near the cutting edge. This material then produces an effect similar to that of large cutting angles, and a Type I chip may be induced as indicated in Fig. 9. The presence of this built-up edge is usually intermittent, since force variations will permit the escape of the crushed material. For this reason it is often possible to find the defects of chipped or torn grain adjacent to areas of fuzzy grain, as commonly found when surfacing woods such as aspen. It is apparent that this variation of the Type III chip will be encouraged by dull cutting edges for reasons discussed below.

Factors Controlling Chip Formation and Surface Quality

It can be seen from the above discussion that the quality of the surface produced during machining as well as the efficiency of the operation is grossly dependent on the type of chip formation. Ideally, on should strive to obtain the Type II continuous chip for best surface quality and the Type I splitting chip for optimum efficiency of material removal.

The rotary cutting method offers a unique opportunity for combining these two goals. At the time the cutting edge is nearest the surface to be generated, the chip thickness is small and conducive to Type II chip formation if the tool edge is sharp. When the knife position in the work is farthest from the plane of the new surface, the chip thickness is near its maximum and tends to encourage a Type I chip. Examination of planer chips indicates that the change in chip formation is the general rule and that the balance between the types largely determines whether a surface will be good or poor.

Where surface quality is the primary consideration, as in making light

finishing cuts prior to machining with coated abrasives, the rotary cutting process appears to be somewhat inferior to orthogonal or straight-line cutting. A well-designed machine operating on a principle similar to the scraper would seem to be indicated, since it could produce high quality surfaces free of machine marks and give relatively long tool life. In some instances, a rotary cutter and orthogonal cutter might well be combined in a single machine.

In rotary and orthogonal cutting, surface is determined by chip formation, which is in turn determined by many factors, some of which are easily controlled and others for which control is impractical or impossible. In the former group are chip thickness, cutting angle, clearance angle, friction on the tool face, sharpness of the cutting edge, moisture content of the wood, mechanical restrictions of chip formation, and cutting velocity. In the latter are natural variations of the material, the grain direction of the wood, and the physical and mechanical properties of the wood excluding the effects of moisture. Grain direction has arbitrarily been put in the uncontrollable category because in high production machining it is not practical to make certain that cutting against the grain is avoided at all times.

The uncontrollable factors obviously must be accepted as such, and the controllable factors adjusted accordingly. Chip thickness is readily controlled by changes in the depth of cut and in rotary cutting also by changes in the feed per knife. In most instances, the feed per knife is the more practical method and may be accomplished in several ways. The simplest is variation of the feed rate, but in many cases it is necessary to alter the number of knives on the cutter head or the rpm of the spindle in order to maintain production schedules.

While light chip loads will usually be accompanied by good surface quality, it should be noted that minor changes in other factors may permit high surface quality at relatively heavy chip thicknesses. The cutting angle of wood-working knives is one of the most useful of the controllable factors that determine chip formation, since it often can be varied with little difficulty. From the previous discussion of chip formation, it can be seen that the angle of the tool face greatly influences the direction of the stress during cutting. As the cutting angle decreases, the forces parallel to the direction of travel increase while the normal forces decrease, thus encouraging the Type III chip formation. Conversely, as the cutting angle increases, the Type I chip formation is enhanced. Only when there is the proper balance between cutting angle and the other factors controlling chip formation will the continuous Type II chip be obtained.

The clearance angle of cutting tools appears to have little direct effect on chip formation, although it may play an important part in tool life since it determines the amount of material supporting the cutting edge. Sufficient clearance behind the cutting edge is required to prevent excessive contact between the heel of the knife and the work piece resulting from a certain amount of recovery in the wood due to stresses imposed during chip formation.

Of considerable importance is the condition of zero clearance of the land produced by jointing rotary cutting knives in an effort to bring all edges in the same cutting circle, or to rejuvenate dull knives. In conventional rotary cutting, the actual cutting angle and clearance angle of a knife will change along the tool path, since it is trochoidal in form rather than circular as is generally assumed. These changes are such that the clearance angle decreases as the knife proceeds along its path. Consequently, a zero clearance angle will become negative and the wood must be compressed to allow the heel of the knife to pass. This is evidenced by the sound of heavily jointed cutters and the increased power required for operation, as well as by the burnished appearance of the machined surfaces.

Friction between the tool face and the chip determines the ease with which the chip will slide up the tool face and influences the distribution of forces that control chip formation. In general, increased friction tends to increase the forces normal to the surface generated. This may or may not prove to be advantageous depending on conditions. Where a Type I chip is obtained, increased friction by greater surface roughness of the knife face will promote formation of the Type II chip while the reverse is true where a Type III chip is obtained.

The sharpness of the cutting edge is a factor which has received considerable attention in all discussions of wood cutting. However, some observations of the cutting action of dull knives as recorded by motion picture photomicrography are worthy of mention. A dull cutting edge has in effect a compound cutting angle varying from the apparent angle to a large negative cutting angle. When cutting, the unworn portion of the knife face behaves in a relatively normal fashion while the worn portion acts according to the angle formed by a tangent to a given point. Thus, at the tip of the knife, the effect is similar to that obtained with large negative cutting angles and the forces are such that the wood instead of being removed as a chip is actually compressed and passes under the knife. When relatively severe, this results in burnishing of the wood surface and raised grain.

Because of its effect on mechanical properties, the moisture content of wood plays an important role in chip formation. Of greatest importance is the fact that moisture changes will alter each of the various wood properties to a different degree. In general it may be said that as wood becomes drier, the likelihood of a Type I chip becomes more probable for a given set of cutting conditions. Where relatively large moisture changes are encountered, cutting conditions must be altered if optimum surface quality is to be obtained.

Mechanical restriction of the chip during formation is a means of control that has long been recognized. The chip breakers and chip curlers found on jointers and planers are familiar efforts in this direction. Unfortunately, most such devices are of little value since they are placed too far from the area of chip formation to prevent all but the most serious defects.

Placed close to the knife, the chip breaker could be of significant value in minimizing the occurrence of chipped grain caused by the Type I chip under adverse conditions. Similarly, the presence of a well-designed chip curler near the cutting edge of the knife would be of value since it would stress the Type I chip in compression and shorten the cleavage line by causing the cantilever beam to fail more quickly.

It would appear that the present trend toward extremely high cutting velocities is open to question, since velocity alone seems to have little direct effect once static conditions are exceeded, providing that such factors as chip load are kept constant by maintaining a uniform rpm-feed rate ratio. Current use of high spindle speeds to secure lighter chip loads and more knife marks per inch at a feed rate consistent with production demands, in order to obtain satifactory surface quality, is in many cases poor practice. Execessively light chip loads result in rapid cutting-edge degradation, low machining efficiency, and generally increased production costs. A simple adjustment in cutting angles may often prove to be the better way to improve surface quality.

It should be noted that high velocities, as considered here, imply speeds up to 20,000 feet per minute. When

supersonic cutting velocities become available, interesting effects of shock waves may be observed. It has been revealed by the General Electric laboratories that a supersonic microtome used for cutting thin metal sections showed no wear on the cutting edge, the shock wave apparently severing the material ahead of the edge.

There is some evidence that high spindle speeds are desirable when chip marks are a common defect on surfaces. Here velocity still has no appreciable direct effect on chip formation, but has a secondary effect which often is important. When making heavy surfacing cuts or where exhaust capacity is insufficient to remove chips, the centrifugal forces associated with high spindle speeds will often help clear the knives of chips and prevent chip marks. However, it has been found from preliminary experiments that the control of static electricity may be a more efficient method of eliminating this defect.

Conclusions

The wood cutting process involves the formation of basic chip types with associated surface characteristics. When cutting parallel to the grain, chip formation may be classified as: Type I, where splitting ahead of the cutting edge may result in the defect chipped grain; Type II, in which continuous diagnoal shear produces excellent surface quality; and Type III, where compression and shear failures in the wood often cause the resultant surface to be fuzzy. Variation of the grain direction with respect to the cutting path of the tool will alter chip formation due to the anisotropic nature of wood.

Formation of a particular chip type is determined by a number of factors, some of which may be controlled. Knowing certain of these factors, it is possible to adjust the remaining to obtain the desired type of chip formation. Under practical conditions, where close control of variables may be difficult, it should be possible to make a statistical determination of chip type and surface quality.

Drum Sanding Wood Products[1]

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VARIOUS ASPECTS of the drum sander are important for the operator to understand, in order to obtain the best possible job. By using less pressure on the sanding drums, for instance, and crowding the abrasive less, stresses to which individual abrasive grains are subjected are much milder. As a result, the abrasive will stand up to the cut much better.

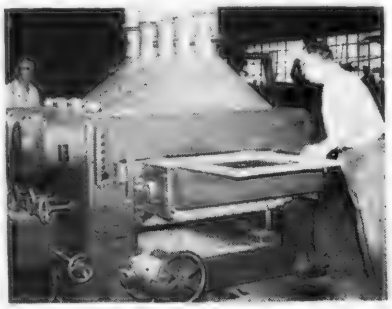
Where coated abrasive is crowded too much, undue stresses set up in abrasive grains and as a result often fracture them long before they are actually dull. In this way, the abrasive breaks away rather than dulling naturally, and costs for coated abrasive become correspondingly high.

Saves Labor and Time

Where more expensive coated abrasive is used to obtain a longer production run, a saving is realized on labor, as well as on actual machine time, because fewer changes of coated abrasive are required in a given length of time. Also, in particular reference to production rates, four-drum sanders can be operated at a higher feed speed than three-drum units without sacrificing any quality on finish obtained. The reason is that the sanding load is divided between a larger number of drums.

All drums on a modern drum sander usually revolve either at 1200 or 1800 rpm. One speed gives better results on some types of work; the other speed performs best on other types. In some cases, however, four-drum machines have been used with 1200-rpm motors on the first two drums and 1800-rpm motors on the remaining drums. Abrasive speed on the sanders in mind is about 3400 surface feet per minute where a 1200-rpm motor is used as against 5200 surface feet per minute for an 1800-rpm motor.

Machine operators often do not realize that where a sander is provided with a heavy cast-iron base, vibration is largely absorbed by this heavy base. Additional weight in a machine is always part of the answer to the vibration problem, although it can never compensate for lack of proper dynamic balancing of the drums. Some of the modern machines have heavy cast iron bases. This, plus the fact that the motors are built in (the rotor for each sanding drum motor being mounted directly on the sanding drum shaft), has much to do with eliminating of vibration and obtaining smoother work.



Four-drum endless-bed sander operating on open screen door frames in plant of Lafitte Sash and Door Co., New Orleans.—Photo courtesy of Solem Machine Co., Rockford, Ill.

Modern endless-bed sanders often incorporate great accuracy. The rubber-cushioned face of the bed is perfectly parallel with the axes of the different sanding drums. The bed is designed to feed smoothly. Any case where jerking of an endless bed occurs, or hesitation in travel, tends to mark the stock under the revolving drums.

It is important that a drum sander have an adequate exhaust fan system and competent exhaust hoods. If blower facilities are not what they should be, dust will not be carried away properly. When sander dust is not removed adequately, it inevitably settles down on the bed. Some of it may work its way down into the feeding mechanism and interfere with smooth feeding. A power driven brush for cleaning the bed continually is helpful in any case where the exhausting system is inadequate.

[1] A contributed article.

Time Study Methods for Furniture Plant Rough Mills[1]

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Describes how time and cost studies may be conducted on operations required to make rough hardwood lumber. Illustrations are given of time studies for several operations in a furniture plant rough mill. Methods are described for converting operating times to a cost per unit foot basis.

HARDWOOD LUMBER is a semi-processed type of raw material. When delivered to a furniture plant from a sawmill, it is not ready for machining into furniture parts. It must first be conditioned to bring it to proper moisture content, and then processed to remove defective portions and to size it for machining.

Rough hardwood lumber of shop grades has uniformity only in its thickness, and even that is only approximate. Within each thickness, the lumber grades[2] specify the minimum length and width of boards, and also the amount of clear wood which must be present in a grade. These specifications, however, allow any range of sizes as long as they are above the minimum. They also allow many defects, provided that required percentages of clear lumber may be obtained in allowable cutting sizes between the defects. Defects may be located almost any place in a board, so it is impossible to cut it to a prescribed pattern.

In order to obtain the best yield from hardwood lumber, it is usually necessary to make more than one cutting size from a board. Different parts of a board, therefore, will almost certainly be made into different furniture parts.

Under such conditions, it is difficult to make time studies and to determine costs for individual operations or for cuttings of different sizes. It is even more difficult when these cuttings may be made from any of several lumber grades. The purpose of this report is to show how time and cost studies might be conducted on operations required to make rough hardwood lumber.

Rough Mill Procedure

The rough mill in a furniture factory is the department in which rough lumber is broken down to sizes required for machining of furniture parts. The normal sequence of operations is as follows:

1. Cross-cut the boards to required cutting length with a cut-off saw.
2. Plane one side of the cut stock on a face planer to obtain a flat face.
3. Pass the stock through a surfacer to plane the back face. This operation is sometimes combined with operation 2 in one machine.
4. Pass the stock over an edge jointer to obtain a straight smooth edge which will serve as a reference edge at the ripsaw. Some plants prefer to joint both edges in the belief that with two reference edges, considerable time can be saved at the ripsaws. Some other plants do no edge-jointing.
5. Rip the stock to required cutting width.
6. Glue the stock to required cutting widths.
7. Plane to required thickness.

All stock normally proceeds through steps 1–5. Some finished cuttings might result after ripping and then go directly to the machine room for further machining. Other pieces might skip step 6 and emerge from the planer as finished cuttings. Still other pieces might be completed cuttings right after gluing at step 6.

Direct Labor Cost for Cross Cutting

A time study of one grade of lumber does not apply to lumber of another grade. A time study of the Firsts and Seconds grade would show relatively little waste time or extra time for removing defects, because the boards would be relatively clear. The cut-off saw operator would have little trouble sizing up a piece to get the most out of it. With lower grades, however, there would be more nonproductive time.

When the better grades are cut, the cuttings which are produced may be of relatively uniform length, whereas with the lower grades, the cut-off saw operator must try to fit various required lengths into the natural clear areas of the boards.

The data for the cut-off operation should be recorded on a time study observation sheet. Time elements at the cut-off saw are as follows:

1. *Get*—The stopwatch reading is taken at the time the sawyer first touches the board. He then pivots the board onto the saw bench, advances it to cutting position, and pushes the saw-feed button.
2. *Cut*—The stopwatch is read at the time the saw enters the first cut. The operator advances the board to the next sawing position and pushes the saw feed button. The interval between readings 2 and 3 is the time required to make the first piece of cut stock.
3. *Cut*—(Same description as element 2) The interval between the third and fourth readings is the time required to make the second piece of cut stock.

"n" *Cut*—The reading taken at the time the saw enters the last cut on a board. The operator releases the last cutting and moves to the feed conveyor to get the next board.

During the cut-off operation, if more than one cut is needed to remove defects or attain the proper length, the time of the first cut is recorded, and the total number of cuts taken in that series recorded in a circle beside it. Other nonproductive work which affects the time needed to cut a piece is time taken to measure the width of the board or to turn it over to look at the other side. An encircled "m" should be recorded beside the time of any element lengthened by measuring. Any

[1] A contributed paper. First in a series of three papers on the relationship between lumber grade and conversion cost in furniture plant rough mills.

[2] Rules for the measurement and inspection of hardwood lumber. National Hardwood Lumber Association. Chicago.

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element that includes a turnover of the board would have an encircled "t."

The first and last elements for each board remain relatively constant. This is because they represent move elements and not productive elements. Under the same work conditions, they should not vary greatly between boards. The productive elements, on the other hand, should reflect the difference in time to handle different cut stock lengths, and also the amount of time necessary for the sawyer to size up the piece to get the best combination of cutting lengths.

In order to determine the effect of cut stock length upon cutting time, the length of each piece cut must be recorded by a time study helper on a separate form. If the times and cut stock lengths for each board are taken in sequence, the time required for each length may be determined by recording time and length data (Table 1). From the data in this table, the footage and time for each length may be computed. The total time, total number of pieces, recut pieces, strokes of the saw, and time, should then be recorded (Table 2). From these, the time per piece exclusive of recutting time may be computed. This, multiplied by the number of pieces produced in each length, results in the total time to cross-cut that particular length group. Total times should be recorded as in Table 3.

If boards are graded and measured before cross-cutting, and the cuttings are measured after cross-cutting, the cut-stock yield footage and yield per cent may be obtained. Rough footage, yield footage, and the total expired time for each run should be recorded as in Table 3. The remainder, after the cutting time is subtracted from the total expired time on Table 3, gives the handling and moving time, consisting of the first and last elements of the time study for each board, plus minor time losses to measure or size up the board. This may be referred to as handling and miscellaneous time. It is most easily expressed on a net foot basis, obtained by dividing the total handling time required at the cross-cut saw for a lot of lumber by the final net yield in board feet from the lot.[3]

Table 1.—TIME AND LENGTH SUMMARY

Grade No. 2A Com
Species Yel. Pop.
Cutting Length Summary
Thickness 4/4
Cutting Length and Time*
Sheet No. 15
Tallye Sheet No. 15
Footage**

Board No.	Footage	1	2	3	4	5	6	7	48"	30"	15"
35	10.00	30 4 15	15 6	48 6	30 5	30 9	15 3	--	2.50	4.68	1.56
36	10.67	48 5	30 5	15 6	15 4	30 3 12	30 6	15 5	2.67	5.01	2.49
Totals	119.17								40.01	41.95	23.04

*In each block, upper figures represent cut-stock length, lower figures represent time, and bold face figures represent delays or the number of extra saw cuts.
**Rough lumber board footage.

Table 2.—TIME SUMMARY WORK SHEET

Grade No. 2A Com — Species Yel. Pop. — Thickness 4/4 — Sheet No. 15

Length (1)	Total time* (2)	Number of pieces* (3)	Average time (4)	Total time re-cut pieces* (5)	Number of pieces re-cut* (6)	Total time pieces not re-cut Cols. 2-5 (7)	Number of pieces not re-cut (8)	Average time not re-cut pieces Cols. 7-8 (9)	Not re-cut average K re-cut pieces Cols. 9 x 6 (10)
48	1.42	17	.084	.63	6	.79	11	.072	.432
30	2.62	30	.087	1.34	9	1.28	21	.061	.549
15	1.61	30	.054	.08	1	1.53	29	.053	.053

*Columns 2, 3, 5, and 6 are from Table 1 and are found by summing the number of pieces and times for re-cut and non-recut pieces in each length class.

Table 3.—CROSS-CUT TIME SUMMARY

Time, Minutes

Group** (1)	Rough footage (2)	Cut-stock yield (3)	Cut Length, inches 48* (4)	30* (5)	15* (6)	Total productive (7)	Total expired (8)	Handling and Misc. (9)
F R R 1	157.20	151.10	2.283	.912	.432	3.627	5.057	1.430
F R R 2	154.72	147.44	2.596	.717	.287	3.600	5.025	1.425
F X R 1	149.27	144.21	2.073	.822	.316	3.211	4.603	1.392
F X R 2	163.91	157.21	2.558	.823	.391	3.772	5.295	1.523
	625.10	599.96				14.210	19.980	5.770
S R R 1	157.83	148.51	2.564	1.110	----	------	------	--
S R R 2	152.15	-------	----	----	----	3.807	6.440	2.633
	481.09	432.40				17.014	26.780	9.716
	1637.01	1496.74				50.627	74.740	24.113

*From Table 2, columns 3 x 9 or cols. 7÷10. It is the time to cut the given quantity in each length excluding deductions for measuring, delay, and re-cutting.
**Symbols are for group identification, each group having fifteen boards. Groups starting with F are Firsts and Seconds; S, Selects; 1, No. 1 Com.; and 2, No. 2 Com.

Average productive cross-cut time per piece for each length in each group is taken from Table 2, column 9, and plotted on cross section paper. A curve is then drawn.

Direct Labor Cost per Net Foot for Cross-Cutting

Cross-cut time may be converted to cross-cut direct labor cost per net foot as follows:

1. The average rough footage of pieces of yellow poplar 4/4 cut stock thirty-six inches long cut from No. 1 Com. lumber is approximately 1.875 bd. ft.
2. This must be reduced by 5 per cent shrinkage allowance and multiplied by the final yield per cent to find the expected net yield footage (1.875 x .95 x .682)—1.215 ft.
3. The Handling and Miscellaneous time consumed in processing this amount of cut stock is equal to the net footage multiplied by the Handling and Miscellaneous time grade factor (1.215 x .023—see footnote 3)—.0290 min.
4. The time to cross-cut 36-inch lengths should be taken from the time curve. It is .0640 min.
5. The Handling and Miscellaneous time and the cross-cut time should be summed—.0930 min.
6. The cut-off time should be increased by 30 per cent—the time consumed by various off-time allowances such as machine set-up, knife grinding, etc. This results in the total time per piece (off-time allowance as found in three furniture plants are summarized in Table 4 for several rough mill machines)—.1209 min.
7. The total time must be divided by the net footage (.1209 ÷ 1.215) to get the time per net foot—.0995 min.
8. The direct labor cost per net foot is the net footage time multiplied by the labor cost per minute. Labor cost may be assumed to be $4.75 per hour or $0.0791 per minute for a sawyer and two helpers. (.0995 x .07917 = $0.0079.

[3] Handling and miscellaneous time per net foot is found by dividing Table 3, Column 9 subtotals by the final finished footage yield for that lot of boards. In the study in which this method was developed, final yield percentage of rough lumber footage was as follows for each yellow poplar grade: FAS, 86.0%; Selects, 77.1%; No. 1 Com, 68.2%; and No. 2A Com., 57.6%. 86 per cent of the FAS rough lumber footage in Table 3 is 625.10 x .86 = 537.59 board feet. If this handling and miscellaneous time subtotal, 5.770 minutes, is divided by the yield footage, 537.59 net feet, the quotient is the handling and miscellaneous time per net foot for the lumber grade. Handling and miscellaneous time grade factors for yellow poplar in one plant were determined to be: FAS, .011; Selects, .013; No. 1 Co., .023; and No. 2A Com., .035.

Table 4.—ROUGH MILL OFF-TIME* ALLOWANCES IN THREE FURNITURE PLANTS

Plant	Time Checked, consecutive minutes	Operation: Cut-off Off-time minutes	Cut-off Per cent of total	Cut-off Allowance per cent	Face Plane Off-time minutes	Face Plane Per cent of total	Face Plane Allowance per cent	Surface 1 side Off-time minutes	Surface 1 side Per cent of total	Surface 1 side Allowance per cent	Edge Joint Off-time minutes	Edge Joint Per cent of total	Edge Joint Allowance per cent	Rip Off-time minutes	Rip Per cent of total	Rip Allowance per cent
A	1620	483	29.8	30.0	----	----	----	----	----	----	----	----	----	240	14.8	15.0
B	540	135	17.8	18.0	129	23.9	25.0	137	25.4	25.0	----	----	----	----	----	----
C	1040	427	41.1	40.0	----	----	----	246	23.7	25.0	253	24.3	25.0	----	----	----

*Off-time includes all time chargeable to the operation during which either the machine or labor was not functioing, Principal times included are: machine down time for maintenance or repair, clean-up around the machine, morning and afternoon rest periods, operator's personal time, and delays for material handling.

Direct Labor Cost for Rough Surfacing

In rough mills in which the surfacing machines are connected to the cut-off saw by a conveyor, cuttings proceed from the cut-off saw through the face planer and single surfacer and possibly on to a double-edge jointer without being touched by man. The time charge for cut-off is also consumed by the other operations, but no time should be charged to them. In some plants, however, cut-off stock must be wheeled on trucks from the cut-off saw or storage area to the finger jointer. The operator then picks pieces up and feeds them to the machine. As pieces emerge they are picked up by the helper and placed on another factory truck. An identical procedure is repeated at the single surfacer.

The time required to surface lumber of different lengths may be determined by feeding 100 pieces in each of several lengths of cut-stock through the surfacer. The total time to run each lot should be taken. Time for interruptions in the process should be subtracted from the total time. The productive time per piece is found by dividing the total productive time by the number of pieces. Productive time per piece for each length should then be plotted on cross section paper and a curve drawn.

Direct Labor Cost per Net Foot for Rough Surfacing

A procedure similar to that used to determine cross-cutting direct labor cost may be used to determine rough surfacing direct labor cost. Pieces which are surfaced are cut-stock pieces. Much defective wood and waste has already been removed by the cut-off saw. More will be removed at the rip saw. Percentage reduction in footage to account for the loss at the rip saw will be the per cent of loss between the cut-off saw yield or cut-stock footage and the final yield after ripping. The determination of yield per cent of cut-stock footage is shown in Table 5.

The following example for 36-inch length cut-stock cut from 1-inch No. One Common black cherry shows how the surfacing cost per net foot may be found:

1. The footage for 36-inch length cut stock of average width is approximately 1.875 bd. ft.
2. The final net yield will be only 72.3% (Col. 7, Table 5) of the base footage (1.875 x .723)—1.356 bd. ft.
3. The time to surface the piece is taken from the time curve—.084 min.
4. This time must be increased by 25% for off-time allowance (from Table 4)—.1050 min.
5. The time divided by the net footage gives the time per net foot .1050 ÷ 1.356—.0774 min.
6. If the labor rate is $0.05417 for the operator and one helper the direct labor cost per net foot will be .0774 x $0.05417—$0.9942.

Table 5.—YIELD PER CENT OF CUT-STOCK FOOTAGE

Grade	Base Footage (1)	Less 5 per cent shrinkage (2)	Cut-off yield per cent (3)*	Cut-off yield Cols. 2x3 (4)	Final yield per cent (5)	Final yield per cent (6)	Per cent final yield of cut-off yield col. 6÷col. 4 (7)
FAS	1000	950	94.4	89.68	86.6	82.27	91.7
Sel	1000	950	92.7	88.07	75.0	71.25	80.9
No. 1 C	1000	950	92.6	87.97	66.9	63.56	72.3
No. 2 C	1000	950	88.8	84.36	55.0	52.25	61.9

*Cut-off yield per cent is from Table 3, Col. 3 divided by Col. 2. The above is from a study of 1-inch black cherry.

Direct Labor Cost per Net Foot for Edge Jointing

When the edge-jointing operation is part of a conveyorized line, no labor can be charged against it. However, in mills where edge jointing is a separate operation, the cut-off stock stacked on trucks must be wheeled from the single surfacer or storage area to the jointer. The operator feeds the stock into the machine by hand. As it emerges it is picked up by a helper, turned over to put the unfinished edge down against the knives and fed back through the opposite side of the machine. The operator then stacks it on a factory truck. The operator must not only feed the machine but must off-bear from it. Computations of time per piece and direct labor cost per net foot are performed in the same way as those for surfacing operations.

Direct Labor Cost for Ripping

At the cut-off saw, the total operating time consisted of: (1) the productive operating time, (2) the nonproductive operating time, called handling and miscellaneous, and (3) off-time allowances. The productive time was based on time per piece, which can readily be converted to time per net foot. The handling and miscellaneous time was not dependent on the time per piece, but on the number of boards cut and the amount of defects in the boards. These were dependent on the rough footage in the various lumber grades. Allowances were simply percentage increases of total operating time to account for personal time and other assorted down times. Handling and miscellaneous time was separated from productive time, because it was not based on the time consumed to produce the cut stock piece.

At the rip saws, the situation is somewhat different. Total time is made up of the same three components. However, both the productive and nonproductive times can be related to the time required to rip the cuttings. There is therefore no need for separating them to find the time per net foot.

Ripping Time and Direct Labor Cost per Net Foot

Since only one rip cut is required to produce some finished cuttings, and several cuts are required for others of the same size, it is difficult to obtain exact times for each individual cutting. To get times for the different widths in each length, the cut stock is sorted into small lots. Each lot is cut for a single width, and stock which will not make the width after removal of the piece should not be passed back to the sawyer, but held until the next lower width class is cut. The total time for each lot is taken, and divided by the number of pieces produced to get the time per piece. The process should be repeated for each cutting length and width class.

Interruptions in the ripping process should be timed and subtracted from the total time for each lot to give the ripping time for the lot. If the time for the lot is divided by the yield

footage after ripping, the quotient is the time per net foot for ripping.

As for other operations, the ripping time must be increased for off-time allowance. This is shown in Table 4 to be approximately 15 per cent. The resulting time, multiplied by the labor cost per minute for the rip saw operator and helper, is the direct labor cost per net foot.

Direct Labor Cost for Edge-Gluing

Edge-gluing may be performed on hand operated clamp carriers or by high-frequency glue-bonding presses. A study of edge-gluing cost was made on a high-frequency press to show the type of time study necessary for the edge-gluing operation.

The stock to be glued was taken from the storage area and wheeled on factory trucks to the press. The operator then placed the stock on edge, with edges to be glued down upon a slat conveyor. It was then carried over a rotating glue spreader roll, which deposited glue on the lower edges and moved it on to another section of the slat conveyor where the forward motion of the stock actuated an automatic stop.

The operator picked up the pieces and assembled panels on a lay-out table. When complete, panels were slid sidewise into the press opening. The start button was then depressed, the upper platen lowered on the panels to keep them aligned, and horizontal pressure applied by an air-powered pressure bar. The glue was set by high-frequency heat. Time of curing depended on the species and thickness of the wood and varied from .5 to 1.5 minutes. Except in a few larger sizes, machine time was less than man time so differences in curing time between thicknesses and species may be ignored. At the end of the press time, the machine opened automatically and the glued panels were ejected by an air-powered ram onto a catch tray. The operator, who had been laying up the next load during the curing time, then piled the glued-up panels on factory trucks with stickers between the layers. Completed jobs were stored in a warm room to harden the glue and equalize the moisture at the glue line.

In order to determine the time required to glue pieces of different sizes, 36 complete jobs were timed. The times recorded were:

1. The start of the machine.
2. The start of the layup of the first panel in each job.
3. The time of depressing the start button.
4. The opening of the press. (After the first set of panels were glued, only the closing and opening of the press were timed until the ejection of the last load for the job. Times for items 5–8 were taken after the gluing had been completed.)
5. Complete piling panels on a factory truck.
6. Dispose of truck to storage area.
7. Find next job, and wheel it to the high-frequency press.
8. Change the machine for different panel thickness when necessary.

The following information should be obtained for each job when making the time study: piece number, species, number of pieces in the job to be glued, length, width and thickness, number of pieces per machine load, time per load, and total elapsed time per load. From this information the productive time per piece may be determined. Productive time per piece should be plotted over the number of pieces per load, then a curve should be drawn. Corrected time per piece may then be read from the curve.

The total time to edge glue a job is made up of the following components:

1. *The productive run time.* This is the time per piece multiplied by the number of pieces to be glued. It tends to be constant per piece for any given number of pieces per load, but varies between jobs, because of the difference in the number of pieces per machine load or the number of pieces in the job.
2. *The non-productive run time.* In most job orders, the number of pieces to be glued is not an exact multiple of the ideal number of pieces per load. An extra run must, therefore, be made to glue up the leftover pieces. Also, there is occasionally a need to re-run pieces that did not glue properly the first time in the machine. Extra time must be allowed to provide for re-runs and for minor down times, such as picking up pieces which have slid off the catch table, pouring glue into the glue reservoir, and scraping caked glue from the conveyor or lay-up tray. Extra time may be found by subtracting the sum of the productive times for all jobs studied from the total elapsed time for the jobs. Extra time per cent is found by dividing extra time by the total productive time, and multiplying by 100. In the study it averaged 21 per cent for a one-man operation.
3. *The machine set-up time.* The average time taken per job for machine set up was 3.26 minutes for both one-man and two-man operations. This amount of time should therefore, be added to the time for each job run through the machine.
4. *Change job time.* The average non-productive time consumed between jobs in moving trucks and pallets, finding the next job, and hunting for the lift truck was 5.00 minutes per job for one man and .75 minutes for two men.
5. *Machine down-time.* This non-productive component occurs when the machine or the operator is not functioning. Included are:
   a. Operator's personal time.
   b. Machine clean-up time at the start and end of each morning and afternoon.
   c. Glue mixing time.
   d. Time consumed by supervision for giving instructions.
   e. Miscellaneous.

In this study, these causes accounted for an average of 155 minutes per day, representing 28.7 per cent of a 540 minute working day or 40.3 per cent of the working day exclusive of down-time.

Edge gluing time per piece must be based upon jobs of average size, since it will change as the number of pieces in the job change. If the average number of pieces per job is assumed to be 150, the edge gluing time per piece may be found as follows, if 20 pieces of a cutting size may be loaded into a machine and the machine is operated by one man:

Number of pieces	150	
Productive time per piece	.164	
Total productive time (150 x .164)		24.60 min
Extra time (21%)		5.17
Set-up time		3.26
Job change time		5.00
Total		38.03
Down time 40.3% of total		15.33
Total		53.36
Total time per piece $\frac{53.36}{150}$ =		.356

When the operator has a helper, not all the machine down-time can be charged against the helper. 90 down-minutes come at the beginning and ending of each morning and afternoon when fresh glue must be mixed or the machine cleaned. The helper is working elsewhere during this period so his time may not be charged against the operation. Daily time for two men is then distributed as follows:

	Operating Time	Machine Down Time	Total
Operator	385 min.	155 min.	540 min.
Helper	385	65	450
Total	770	220	990

For two men, the down-time is 220 minutes out of the 990, or 28.6% of the operating time.

Conclusions

It is impractical to illustrate all the different types of time studies which might be used in furniture plant rough mills. The illustrations given, however, should serve as a guide for anyone wishing to make rough mill time studies.

The determination of the time per piece to process cuttings of different sizes on rough mill machines, and the conversion of time per piece to direct labor cost per net foot are demonstrated. For some purposes such as comparing operating methods, the time alone might be a sufficient basis on which to make a comparison. However, when planning a rough mill operation for production of cuttings at the lowest possible unit cost, the conversion of operating times to a cost per unit foot basis should be helpful.

Probably the most important use to which information of this type might be put is to aid in the choice of lumber grades for producing cuttings of different sizes and from different species. Other uses to which it might be put are in choosing machinery for production jobs, planning the layout of a rough mill, evaluating the labor in a rough mill, costing the cuttings produced in the rough mill, and as a guide to the furniture design department to indicate which types of design might be produced at the lowest unit cost.

New Potentials in Fibers and Chemicals from Wood Waste[1]

FRANCIS H. SNYDER

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Describes new product and process developments employing whole wood substance as the primary raw material, including a potentially significant material known as "Dendrol". Latter has some properties of thermosetting phenolic resins, thus suggesting a variety of industrial uses. Also discussed are other chemicals and resins produced from wood waste, a new process for pulping hardwoods, and uses for lignin derivatives.

Introduction

THE EVENTUAL CREATION of a vast organic chemical industry based on wood-substance as the primary raw material seems inevitable. How soon this will come about is unpredictable at present. Whatever the magnitude of our reserves of petroleum, natural gas, and coal may be, these basic raw materials of the organic chemical industry are both limited and irreplaceable.

Wood in the form of logging and mill residuals is available, or can be made available in enormous quantity. The sum of the wood-substance cut and left to rot in the woods and the unused portions of the logs which accumulate in lumber and plywood mills amounts to about 65 million tons annually. Another source of cheap wood substance is represented by trees which should be cut out of the forest but are left standing because they have, for one reason or another, insufficient value by present-day standards to pay for their harvesting. The total mass of wood substance potentially available as chemical raw material is, therefore, about 100 million tons annually.

The problem of gathering forest residuals for processing must not be underestimated. A great deal of money and ingenuity will be required to develop the low-cost methods of harvesting and delivery to process plants which are prerequisites of large scale utilization. Mill residuals, amounting to about 35 million tons annually, have already been harvested and are much more readily available.

Those who are interested in the development of the wood-chemical industry must face the fact that raw material is not going to be obtained for nothing. Fundamentally, and for the long pull, we are going to do what the lumber industry has to do: go out in the woods and bring it in. Only the large lumber companies (and there are not many of these) produce enough residual material to supply a chemical operation of any considerable size. These companies are already using a large proportion of what used to be waste in the manufacture of useful products. The removal of bark from saw-logs results in the production of clean slabs and edgings which are chipped and sold to the paper industry to the great advantage of both the buyer and the seller. The conversion of scrap wood into composition boards of numerous kinds is already big business and is destined to grow at an accelerating rate.

Wood as a Chemical Raw Material

The organic chemical industry has enjoyed a fantastic rate of growth for the past 20-odd years. A generation ago the organic chemical business was usually thought of in terms of coal-tar derivatives such as dyestuffs, pharmaceuticals, explosives and the like. The petrochemical age was still pretty much in the future less than thirty years ago. Since that time, billions and billions of dollars worth of new products have been created and sold. A large percentage of the new chemicals, fibers, plastics, drugs, and specialties went into production before a demand existed for them. The organic chemical industry has made a fantastic success of the business of making and selling products for which there is no demand. This became possible when management of chemical enterprises was taken out of the hands of the bankers and put in those of the industrial chemist.

Every known organic chemical could, conceivably, be made from wood. The crux of the situation is economic. The development of a real chemicals-from-wood industry will depend upon fundamental research into the nature of wood and its chemical constituents and the creation of basically new processes, products, and markets based on this knowledge. The wood-chemical industry will have a character of its own: it will mimic neither the products nor the philosophy of any other.

[1] Presented at Session VI, Chemical Utilization, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

The Author: Francis H. Snyder was first employed as a chemist in a TNT plant in upstate New York at the age of 16. At 19 he was chief chemist of a plant in Indiana, directing research on dyestuffs and intermediates. He later attended Syracuse U., became a consultant in 1926. From 1947–51 he operated Snyder Chemical Corp., manufacturer of synthetic resins.

This is a field wherein the efforts of the inventor, the enthusiast, and the uninhibited are needed. A large amount of patient money combined with a far-ranging intellectual approach is required in this entrancing field of reesarch.

This discussion relates some of the efforts of our organization together with some of our associates in the broad field of product and process development, employing whole wood substance as the primary raw material.

Continuous Hydrolysis of Wood

S. M. Nickey, Jr. and W. Jeter Eason of Nickey Bros., Inc., Memphis, Tenn., with Lawrence D. Kellogg of the L. D. Kellogg Lumber Co., Alexandria, La., sponsored a research program early in 1950 at Southern Research Institute, Birmingham, Alba. The purpose was a study of the chemical utilization of waste wood on a broad front. This program was directed by Dr. Reavis C. Sproull, FPRS Chemical Utilization Committee Chairman, who at that time was head of the Wood and Paper Section at SRI. Working with Dr. Sproull was D. L. Kenaga and L. C. Wallace, who conceived a continuous process for the acid hydrolysis of wood to produce sugars and a lignin by-product. The writer was retained by the sponsors as Consultant in late 1950 and worked closely thereafter with the staff at SRI.

A successful process and apparatus was developed by the SRI staff and the process was approved by two large chemical engineering and consulting firms. The economics of wood-hydrolysis generally, however, did not appear attractive and the project, while a great technical achievement, could not at that time be commercialized. The firm of Arthur D. Little, Inc. reported on the process and concluded that it merited further study on a somewhat larger scale.

Meanwhile, the writer conceived a new type of process operated at higher temperature and at short times of contact. Upon disclosure of this idea to Arthur D. Little, Inc., the latter recommended to the sponsors that it be investigated. A development group composed of Messrs. Nickey, Eason, Kellogg, and the writer was organized under the name Dendrol, Inc. This company has conducted much of the work reported herein. Pilot scale studies and technical and economic evaluations have been conducted by the staff of Arthur D. Little, Inc., in cooperation with the writer. Specific product development has been undertaken in the laboratory of Francis H. Snyder & Associates during the past year.

I. Chemicals and Resins from Wood Waste

Initial work by Dendrol, Inc. was directed to a study of the acid catalyzed hydrolysis of wood chips at high temperatures, i.e., in the range of 225–285° C. which includes the exothermic pyrolysis temperature of ligno-cellulose. Wood chips or hogged mill wastes were treated with very small amounts of sulfuric acid by spraying dilute acid on the chips. The chips take up from 5–15 lb. of actual sulfuric acid per ton of dry wood substance (DWS.) The chips are drained and charged to a carbon steel tubular reactor and brought up to the chosen temperature with direct steam. Reaction times of about sixty seconds gave quite complete conversions to the products described below.

The crude product consisted of a solid dark brown lignin derivative which we call Dendrol and an aqueous solution containing acetic and formic acids, furfural, 5-(hydroxmethyl) furfural (HMF), traces of other furan derivatives, and recoverable amounts of methanol and ketones. The yield of lignin derivative was usually about 150–200 per cent, based on the lignin in the raw wood. The increase in weight was due to condensation of the lignin-degradation products with furfural and HMF. Reducing sugars and pentose sugars were found in small yield, usually amounting to less than 1 per cent of theory.

A great deal of effort was expended in a study of the properties of Dendrol. It was found to be highly phenolic in character and was soluble in dilute alkali or aqueous acetone to the extent of 60–95 per cent. Under the microscope, the product appeared as light brown, transparent beads of congealed liquid. There is no doubt that the product was liquid at the reaction temperature. The softening point of the solid product varied with reaction conditions and particularly with liquid wood species. Aspen Dendrol, for example, fuses before the boiling point of water.

Dendrol was found to have somewhat the properties of thermosetting phenolic resins. When spread on the hot-plate with a spatula the material fused and then set up at quite rapid rates. This suggested the use of the material in molding compounds and a considerable number of these were prepared and tested. These performed well in commercial tests except for a tendency to stain the molds. This was later overcome by thorough washing of the material with hot water before compounding.

A study of the aqueous hydrolyzate was started in late 1952 and the compounds referred to above were identified and isolated. The total yield of furan aldehydes from oak is about 18 per cent. One third of this is furfural and the other two-thirds is a mixture of 5-(hydroxymethyl) furfural and its bi-nuclear ether.

These furan yields compare favorably with those obtained from oathulls and corncobs. Much higher yields are possible by a different process, described in the second section of this paper.

HMF is an interesting substance. It is not an article of commerce, never having been produced commercially. It is an extraordinarily reactive chemical containing a primary alcohol, an aldehyde, and a conjugated double bond system in the ring. Several patent applications covering synthetic resins derived from HMF have been filed.

The reduction of HMF to the dimethylol derivative is accomplished readily. Dimethylol furan (DMF) is a promising material on account of its potentially low cost and extreme reactivity. It polymerizes rapidly but under nice control in the presence of acid catalysts to yield a jet black, glossy resin which is immune to both acids and strong alkalis. Strong oxidizing agents attack it. It also condenses with other alcohols to form polyalcohols and with acids to form polyesters. The tetrahydro derivative has great possibilities as a plasticizer raw material. Since DMF has a very high boiling point, it can replace furfuryl alcohol in many applications such as the production of acid-proof cements and coatings where the high volatility of furfuryl alcohol limits or complicates its use. DMF applied to wood may be polymerized in situ to confer great chemical resistance, hardness and dimensional stability.

II. Fibers and Plastics from Wood Waste

The work outlined above indicated that we were dealing with a phenomenon of more than ordinary interest: the great chemical reactivity of wood substance in the vicinity of the critical temperature of ligno-cellulose, 273°C. Fundamental studies of the behavior of wood with various catalysts and with various reagents in the critical temperature range were undertaken. A study of one of these possibilities led to the development of a new pulping process which may have considerable impact on the paper industry and on the plastics industry.

It became apparent in the study of the acid-catalyzed reaction that the acid was serving to trigger the reaction but was not behaving as a

strong acid. The pH of the reaction product ranged from 2.8 to 3.1. This is the pH of an acetic acid solution and not that of a solution of sulfuric acid. The amount of acid employed is less than is required to convert the mineral cations of the wood-ash to sulfates. The process is, therefore, autocatalytic, in the sense that acetic acid, liberated from the wood in the early part of the reaction cycle, is probably the working catalyst.

It was found that sodium sulfate has about the same effect as a hydrolysis catalyst as does sulfuric acid in this temperature range. Experiments were run with other salts and with bases and only the rate of the reaction was affected. When a buffer was used, more or less of the carbohydrate fraction of the wood survived. Further study of this effect showed that when the system was adjusted so as to produce a final pH just under 7.0 at a reaction time of about one minute, a satisfactory yield of fiber was obtained in association with a lignin derivative which is easily removed from the crude pulp by displacement washing with 0.5 per cent caustic soda solution. The washed fiber is light tan in color and is readily bleached, using 2.5–3.5 per cent chlorine to obtain a brightness of 80 to 85 G.E.

The bleached pulps made from typical hardwoods such as red oak and aspen are characterized by great softness, opacity and absorbency, low copper number, high viscosity, and excellent cleanliness. Microscopically, the fibers appear as undamaged cells, almost perfectly separated and exhibiting beautiful morphological integrity. The fibers respond to beating rather slowly at neutrality. High tensile and mullen strengths, reminiscent of the neutral sulfite pulps, are developed rapidly in the presence of a little alkali. The addition of about ten pounds of sodium metasilicate per ton of fiber is sufficient to increase the rate of strength development five-fold and the ultimate beaten strength threefold.

These fibers have been evaluated sucessfully as major components of soft tissues, high grade printing papers and specialties. Preliminary studies have indicated great promise for these pulps as a source of alpha-cellulose for plastics, film, and fiber production.

The pulping of softwoods by this process has not been accomplished. Conditions which serve well in the case of hardwoods do not produce bleachable pulps from Douglas-fir and Southern pine, the two softwood species tested to date. It is expected that further research may alter this situation.

This process differs from others in that primary reaction or digestion does not remove the lignin but converts it by depolymerization and hydrolysis to simple phenolic substances which are readily extracted from the fiber with dilute alkali or polar organic solvents. The crude fiber from the reactor is a medium to dark brown fibrous mass which consists of three physically and chemically distinct fractions. The first fraction consists of the cells native to the wood which has been treated. The second is an amorphous, finely divided substance which appears to consist mostly of the lamellar hemicelluloses. The third is the lignin depolymerization product which occurs as small glassy beads which are easily observed in the microscope at low magnification. These lignin beads are very friable and if the crude pulp is given a light brushing in a disc mill or similar apparatus, a large percentage of both non-fibrous fractions may be removed by selective screening or washing. Up to 80 per cent of the total lignin and up to 50 per cent of the pentosans have been removed from the crude fiber in this manner. The remainder of the lignin is removed by the use of dilute alkali and by the subsequent bleach cycle.

It has been found necessary to process the crude product rather promptly after reaction in order to obtain an easy-bleaching pulp. The lignin derivatives are appreciably soluble in water and tend to diffuse into the cells and there to undergo repolymerization and possibly oxidation. The bleach demand may double in two or three days. This is of no consequence in production, however, since it is usually impracticable to store more than a few hours production of pulp in slush form.

The lignin extract can be kept fairly concentrated with respect to lignin content and the lignin is recovered easily. If the lignin is used for rubber compounding, the alkaline solution is added to the rubber latex and the two coprecipitated. The lignin itself is recovered by carbonation with flue gas or by acidification with sulfuric acid. The lignin is precipitated at a temperature of about 30° C. and the suspension is heated to 60–70 degrees C. to cause incipient fusion of the lignin which is then recovered on a filter without difficulty.

Uses for Lignin Derivatives

The lignin derivative produced as a by-product of this process is a low polymer material having an average molecular weight of about 200–300. It contains at least one phenolic hydroxyl group per unit of molecular weight 170. It has a characteristic phenolic odor similar to guaiacol. It reacts vigorously with furfural or formaldehyde in the presence of bases. It is readily nitrated and sulfonated. It gives few of the characteristic color reactions of lignin with amines, phenols, etc. It is easily oxidized by air yielding a mixture of polycarboxylic acids and other products. It is soluble in dilute aqueous acetone, in 50 per cent methanol, in dioxane, and many polar organic liquids. It is appreciably soluble in xylene and ether. It is insoluble in paraffins and benzene. It is also soluble in many organic bases.

An intensive study of the use of these lignin derivatives is now under way, particularly in the extension of phenolic resins for use in molding maerials, laminating varnishes, hardboard binders, beater-addition phenolic resin papers, and in a number of special applications. In all of these applications it was found that these lignin products could replace from 75 to 95 per cent of the phenolic resin without loss in any significant properties. In all cases the water resistance of the products was increased by the lignin.

Varnishes for paper base laminates are prepared by the addition of the moist precipitated lignin to single stage phenolic resins dissolved in alcohol made slightly basic with ammonia. (Soda lignins have been used to extend phenolic resins in laminates up to a 50–60 per cent replacement of phenolic resin. Above this point the water resistance tends to fall off.)

Excellent molding compounds have been produced on the pilot scale from the new lignins and especially from the crude fiber-lignin product. An extremely cheap and simple method of compounding has been developed which, together with the small percentage of phenolic resin required and the low cost of the fiber-lignin (which is less than the cost of wood flour), enables us to produce fully satisfactory molding compounds at a materials cost of from 3.5 to 5¢ per pound and at an overall cost, including packaging, of from 6.5 to 8¢ per pound.

These materials have had commercial scale testing for molding performance and are in every way acceptable to the molders. These compounds have considerably higher impact strength than the conventional wood-filled materials since they are, essentially, cellulose-filled rather than wood-flour filled. They meet all of the ASTM specifications for both Type 2 and Type 3 compounds. Flow numbers up to about 100 have been obtained in these low cost materials. Wood flour filled compounds can be made in somewhat higher flows than these but it must be remembered that we are

dealing with fiber fillers which give less flow but more impact strength. Still higher degrees of flow are obtainable by cutting the fibers short or by removing the longer fibers by selective screening. The new compounds are fast curing, very clean working, and have beautiful surface characteristics.

It is expected that these new materials will, at the relatively low prices for which they can be sold, establish new markets for themselves. It is estimated that these compounds will be sold at about one-half to two-thirds of the price of comparable conventional materials. Many millions of pounds annually can find a market without taking business away from established producers.

We are aware of previous work by others in this field. The use of lignin or ligno-cellulose in molding compositions has been retarded by the poor flow of such materials and by their tendency to stick to mold surfaces. The first is due to the high softening points of previous lignins and the second is due to inadequate cross-linking of the lignin during the curing cycle. Both difficulties have now evaporated.

The use of the new lignins as extenders of phenolic resins in dry-process chipboards is an important commercial possibility at this time. Compositions in which 90 per cent of the phenolic resin is replaced with lignin appear to serve as well as straight phenolics. The potential saving ranges from $10–20 per ton of production. Modified formulations have been developed which impart elastomeric properties to the binders. Greatly improved machinability is obtained, together with large reductions in tool-wear.

A new type of board has been developed recently in our laboratory in which the wood particles are stabilized by a treatment similar to the procedure which we have developed for the dimensional stabilization of wood in the form of veneer. The stabilizing chemicals are added to the wood particles along with the binder and the reaction which produces stabilization by cross-linking takes place during the hot pressing of the boards. This appears to be an inexpensive approach to the production of dimensionally stable furniture cores, pattern and die stocks and generally where warp and check resistant structural material of low cost is desired.

A modification of the process described herein has been developed which is, in effect, a case of acid hydrolysis of wood catalysed or initiated by strong alkalies. When wood chips are treated with 1–2 per cent of caustic soda (20–40 lbs. NaOH per ton DWS) and reacted at high temperatures for periods of time on the order of two to three minutes, complete hydrolysis of the carbohydrate fraction to soluble sugars and complete depolymerization of the lignin to the highly reactive products described above takes place. Under these conditions, the sugars are not cleaved to the furans but remain as a mixture of pentose and hexose mono- and polysaccharides in solution. The solid product is obtained in approximately 100 per cent yield based on the lignin content of the treated wood. The yield of sugars is also nearly quantitative.

Only traces of furans are produced together with considerable amounts of acetic acid and a little formic acid and methanol. The sugars may be recovered for stock feed by concentration or may be worked up into other chemicals by fermentation or otherwise.

A process has been worked out in our laboratory for the continuous high temperature conversion of these sugars to furans using a non-acidic catalyst. Times of contact of 5–15 seconds at temperatures ca. 230° C. give high conversions to furfural and hydroxymethyl furfural.

Recently, this conversion has been conducted in the presence of phenols with the result that typical novolac resins of excellent characteristics have been prepared in one step from crude sugar solutions. The same process has been applied to blackstrap molasses, to liquors from the prehydrolysis of wood chips for pulping, and to glucose with similar results. Attractive molding materials were made by combining these resins with the lignin coproduct together with a fibrous filler such as wood flour or the crude pulp from the high temperature process.

Synthetic Lumber

One of the best bets for the lumber industry is the development of a good process for making big boards out of little ones. The best way to do this is to take the scrap apart to produce a fiber or flake, and then put it back together with some degree of orientation in such a way as to reproduce as closely as possible the strength to weight relationship which exists in reasonably good lumber. Present hardboards and wood particle boards are a step in this direction. Many of these fall short on account of one or more of the following limitations: they are fal short on account of one or more too dense, too hard, too abrasive to tools, have poor nail-holding ability, inadequate water resistance and dimensional stability, are too costly, or require too much plant investment.

A critical step in this program is the development of a binder which is cheap enough and good enough so that adequate properties can be built into the product. In native wood the binder is lignin, as it is in most wet-process hardboards. The difficulty is to obtain this bond without densifying the board too much. We believe that the new lignins described herein may lead us to a working solution to this great problem. By modification with small amounts of elastomers and cross linking agents, we obtain at once a combination of low cost, high performance, and good machining and nail-holding properties.

Even if the cost of straight phenolic resins could be borne, they would not meet the situation very well or very long. First, there just isn't enough phenol available or prospectively available for the job. Second, the abrasive properties of cured phenolic resin binders would militate against acceptance by the average builder. There is only one good place to find the kind and quantity of binder required to put synthetic lumber on the rails and that is on the scrap pile. On this basis, less than 1 per cent of the weight of product is represented by anything you have to go out and pay money for.

Other Developments in Chemical Utilization

A recent development which is going forward in our laboratory is the production of a soil-improving, organic nitrogen fertilizer by the reaction of low-grade wood waste with anhydrous ammonia at high temperatures and for short reaction times. The product is a dark brown granular mass containing 12–17 per cent nitrogen, about three-quarters of which is organically bound, the remainder of which is in the form of ammonium compounds.

This process seems to offer some attractive possibilities. The lowest grades of wood waste are suitable for reaction after grinding to about one-inch chips or slivers. The process is quite simple and the plant requirements are relatively modest. The process lends itself well to fairly small scale operations and local markets for the product should be available. The product contains both quickly and slowly available nitrogen and the residue is a valuable additive to soils, particularly in cases where high clay content is responsible for poor drainage and tilth.

Lignins, generally, have the property of altering clay soils in such a way as to cause aggregation of the colloidal particles. Not only are drainage and tilth greatly improved but the

soil is considerably stabilized against erosion by rain and wind. Improved yields of many crops have been reported. We have also found that clay, in water suspension, is rapidly agglomerated and precipitated by certain types of lignin preparations.

Industrial sponsorship of this process will be sought to make possible a comprehensive program of pilot scale production and field testing.

Conclusion

The limitations of time and space have kept detailed discussion of these processes and of the properties of products to a minimum. This paper must be considered as a progress report.

Patent applications covering the various developments are on file or in course of preparation. It is expected that the various developments described will be made available to the industries affected under non-exclusive licenses.

Discussion

W. H. Koepp (Mich. College of Mining & Technology): What per cent yield is obtained in this proposed pulping process?

Mr. Snyder: 48–51 per cent from oak; 54–57 per cent from aspen.

Mr. Koepp: What pollution (B.O.D.) developed in the pulping process?

Mr. Snyder: There is no pollution problem since all by-products are utilized except bleach residues.

T. H. Williams (Northwest Laboratories): In high temperature ammonolysis, where does the N hookup occur—in the lignin portion? What type of groupings have you found?

Mr. Snyder: We believe lactam or amino groups are formed, also glucosimines, etc. Approximately 18 to 25 per cent of the total nitrogen distills after treatment with alkali; the rest is apparently carbon bound.

Dr. Jean Mater (Mater Engineering): What is the nature of these lignin derived phenolic substances?

Mr. Snyder: It is very fast setting and acts as if there are more hydroxyls per ring than one.

Dr. Mater: Do the liquid phenolic resins produced react as rapidly as polyhydric phenols or like monohydric phenols?

Mr. Snyder: These are not pure chemicals. The crude phenols have two apparent iso electric points. The material with the lower iso electric point is more phenolic and is believed to be polyhydric.

Dr. Mater: Are they fused in the plastic sense of being polymerized substances of the phenol-aldehyde type?

Mr. Snyder: They melt during formation and are found in the crude product as fused beads, but are still fusible.

E. T. Clapperton (Pope & Talbot, Inc.): Does the wood go through the exothermic reaction stage during the acid cooking?

Mr. Snyder: We don't know. We tried to measure this but there was too much heat present to readily pick up this added heat.

Mr. Clapperton: Does the time of cooking affect the amount of alkali soluble product?

Mr. Snyder: Yes it does.

Reavis C. Sproull (Herty Foundation): Can the polymerization of lignin components be arrested by the use of antioxidants?

Mr. Snyder: A pH of 5.5 gives maximum stability. Antioxidants are not very effective for products formed by acid catalysts but have some effect on those from alkaline catalysts.

L. H. Bock (Rayonier, Inc.): What is the form of wood used in the process?

Mr. Snyder: Hardwood veneer mill wastes—principally oak, walnut, and gum.

Chemical Research on the Utilization of Lignin[1]

ELWIN E. HARRIS

Subject Matter Specialist, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Uses for lignin based on its chemical structure have been retarded by a lack of knowledge of the chemistry of lignin. This problem is being attacked through research on the fundamental structure of lignin, and on the chemical changes that occur when lignin is subjected to various treatments. Knowledge of the various groupings in the lignin molecule may suggest ways of converting lignin present in residues into useful products.

Introduction

THE UTILIZATION OF LIGNIN in residues incurred in logging, milling, and processing of wood presents a challenge to the research man. The problem with some of these residues is to find uses that will overcome the need for special means of disposal. In all cases, it is a problem of finding higher value uses that will make the processing of these residues a paying industry.

Depending on the nature of the product, research on the use of lignin may be divided into four classes. In order of their importance or urgency, the first is the problem of recovery and processing of the lignin in water solution or suspension from sulfite or semichemical pulping of wood. This work has the greatest urgency because the material presents a disposal problem (1)[3]. The second is the problem of finding higher value uses for lignin in spent liquors from alkaline pulping processes. The third is the development of uses for lignin remaining as the solid residue from wood saccharification processes. The fourth is uses for lignin present in logging and milling residues. Lignin in these various residues could supply up to 50 million tons annually (2).

Lignin from Spent Sulfite Liquor

Lignin represents over half of the organic matter in spent sulfite pulping liquor. This material has been the subject of much controversy and much research. The lignin is in the form of sulfonic acids and is mixed with sugars, carbohydrate decomposition products, wood extractives, and pulping chemicals dissolved in water in

[1] Presented at Session VI, Chemical Utilization, Ninth National Meeting, FPRS, June 21–23, 1955, in Seattle, Wash. Read by Dr. Edward G. Locke, Chief, Division of Wood Chemistry, U. S. Forest Products Laboratory.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to literature cited.

The Author: Dr. Elwin E. Harris received B.S. degree from Hamline U., St. Paul, Minn., M.S. and Ph.D. degrees from U. of Minnesota. He taught at the U. of North Dakota and Hamline U. before joining the Laboratory staff in 1930.

11 to 15 per cent solution. For some uses, such as linoleum cement, the whole spent liquor is concentrated by evaporation to a thick paste. Serious scaling develops during the evaporation when calcium salts are used for the pulping. Ammonia, sodium, or magnesium salts are used for the pulping in order to overcome scaling during the evaporation. The spent ammonia base, sodium, or magnesium base liquors are concentrated and burned to recover the chemicals and provide heat for the evaporation and for the pulping process (3).

Utilization of the lignin in these liquors for higher value uses is delayed by a lack of knowledge of the chemistry of lignin and of the manner of linkage of the sulfonic acid group on the lignin.

Most of the applied research on lignin sulfonic acids has been devoted to uses for large quantities and in some cases may be classed as a means of disposal. Spent pulping solutions have been sprayed on dirt roads. The lignin in this case acts as a stabilizing agent for the road foundation, making the road soil more waterproof. The bearing capacity and resistance to shear are increased (4). It is reported that over 60 million gallons of spent sulfite pulping liquor were sprayed on more than 4,000 miles of unpaved roads in Wisconsin in 1954 (5). Because of the large amount of water in spent pulping liquor, the distance unevaporated liquor can be trucked without excessive expense is limited. Evaporated spent liquor has been used for a number of years for road bonding and further experiments are in progress to determine the economics of its use.

Experiments on the use of lignin in spent pulping liquors as a fuel are being carried out at several pulp mills. At one mill (3) wood is pulped by a magnesia-base sulfite pulping liquor. Spent pulping liquors from this process are evaporated in multiple-effect evaporators and the concentrated liquor burned in special burners. The lignin has a fuel value of about 10,000 B. t. u. per pound, dry basis, and supplies heat for the evaporation and the pulping process.

Methods for overcoming the scale produced by evaporation of calcium-base spent pulping liquors are being practiced at another mill. The evaporator has a means of reversing the heating and condensing surfaces at predetermined intervals and scale produced during the heating cycle is removed during the condensing cycle (6).

At another mill, lignin sulfonates are precipitated from solution by the addition of lime (7). This salts the lignin sulfonite out of solution. By careful control of the amount of lime added, a fraction high in organic matter is obtained. This product may be burned or used as the starting material for production of emulsifying agents, vanillin, and other fine chemicals.

Spent liquor freed from sugars by fermentation or by yeast growth is being evaporated and used to supply lignin sulfonates for many uses (8). By the use of a final spray drying, lignin sulfonates are obtained as a tan powder (6). Small amounts of lignin sulfonate ranging from 0.1 to 0.4 per cent added to Portland cement act as a wetting agent and an air-entraining agent. This permits a free-flowing, faster curing mixture of cement and gravel or other components with less water. The air-entraining property makes possible the production of lighter weight building blocks.

Solutions of spent sulfite pulping liquor may be used as a binder for sand molds in a foundry to permit sharper castings and better separation of the castings from the mold.

Lignin sulfonic acid alone or with other agents has the property of fixing protein in hides and is used as a tanning agent (9). This same property causes lignin sulfonic acids to be a precipitant for protein in solution (10).

A paste of lignin sulfonic acid with lead compounds is used to expand the negative plate of acid storage batteries and to give the battery improved properties (11).

Lignin sulfonic acids have emulsifying properties that make them valuable as dispersing agents for water and road oil emulsions and water and asphalt emulsions in the preparation of weatherproof roads.

Lignin sulfonic acid is used as the principal raw material for vanillin production in the United States. Precipitated lignin sulfonic acid, concentrated spent pulping liquor, or concentrated spent liquor after sugar removal by alcoholic fermentation or by yeast production is treated with an excess of sodium hydroxide (12) or lime (13) at elevated temperature in the presence of air or some oxidizing agent. The lignin sulfonic acid is cleaved and oxidized to vanillin, which may be extracted by some solvent such as butanol or toluene and purified by distillation and recrystallization.

Small amounts of lignin from spent sulfite pulping liquors are used for oil well drilling, boiler water treatment, coprecipitation with rubber, ore flotation, and many other purposes. Most of these uses for lignin sulfonic acid do not command a price that justifies processing, because for these uses it must compete with other low-cost materials. Search is being made for uses that employ the specific properties of lignin.

Lignin from Alkali Pulping

Utilization of the lignin in spent alkaline pulping liquors from the soda and kraft processes involves the problem of higher values. These liquors are usually concentrated and burned to recover the pulping chemicals and to supply heat for evaporation and for the pulping process.

About 80 per cent of the lignin in the spent pulping liquor may be precipitated by acidification of the spent pulping liquor to about pH 8. Carbon dioxide from stack gases is usually the acidifying agent. This treatment produces a type of acid-salt of lignin that is only slightly soluble; on standing it settles to the bottom and may be recovered by decanting the clear supernatant liquor and filtering the precipitate. Further treatment of this precipitate with a mineral acid yields an acidic sodium-free form. Treatment with a small amount of alkali produces a soluble derivative. Each of the products have special properties that are being studied.

The products from the soda and kraft process have similar properties except that the kraft process lignin contains sulfur and has thio-phenol groups, while the soda lignin has phenolic groups. The purified form of either product is 90 to 98 per cent organic matter and insoluble in water.

One mill in the United States produces precipitated kraft process lignin from the pulping of southern yellow pine (14) and another produces a precipitated soda process lignin from the pulping of hardwoods (15). Another mill has developed a paper laminated product using lignin as a part of the bonding agent. It is estimated that the pulping industry could make available 2.7 million tons of dried alkaline process lignin a year.

The product is an amorphous brown powder, insoluble in water but soluble in dilute alkaline solutions, formic acid, several amines, glycol ethers, ketones, and phenols. It softens with decomposition at 200° to 250° C. It is highly absorbent toward proteins, high molecular weight organic products, and polyvalent metal ions. It absorbs in alkaline solution up to 2 moles of oxygen for each C_9 unit of the molecule.

Alkaline solutions are emulsifying and dispersing agents and find use in asphalt emulsions, drilling mud, foam stabilizers, mimeographing and printing inks, and in insecticide emulsions. When alkaline solutions of lignin are

mixed with rubber latex and acidified, the lignin coprecipitates with the rubber giving the rubber reinforcing properties. If alkaline solutions of lignin are added to protein solutions, then acidified, the protein is removed from solution. This lignin also forms complexes with calcium and other polyvalent ions that prevent precipitation.

Alkali lignin is high in phenolic groups and reacts with formaldehyde and other aldehydes to form resins. It is used as an extender for phenol in phenol-formaldehyde plastics and resins and paper laminates. Ether and ester derivatives of alkaline process lignin with fatty acids and higher alcohols are wax-like and may find use as water repellents. The uses discovered thus far, except possibly the reinforcing of rubber, are low volume and for the most part low value and would not go far in using the potential 2.7 million tons the industry could produce each year. In areas where coal or other fuels are expensive, the lignin may be more valuable as a fuel. Studies are being made to develop more efficient ways of burning the lignin (16).

Lignin from Wood Saccharification

The acid hydrolysis of wood for sugar production leaves an insoluble lignin residue available for processing. The products from the dilute acid processes involving complete hydrolysis (17) are concentrated acid processes (18) appear to give similar products. The product is insoluble in water and only partially soluble in alkali and organic solvents. It becomes soluble in alkali and organic solvents by heating at 150° to 170° C. in alkali or phenols and is changed to a product similar to alkali lignin but less reactive (19). The solubilized product may be coprecipitated from alkaline solutions with rubber latex. Oxidizing by air or mild oxidizing agents increases its reinforcing properties. The reactive lignin condenses with formaldehyde to form a resin suitable for some plastics.

The insoluble lignin has base-ion exchange properties that may be increased by sulfonation or by condensation with polymeric amines (20).

Unmodified lignin from wood saccharification is not a good plastic molding powder. It has poor flow properties and produces a brittle plastic (21).

Considerable experimental work has been carried out on the use of lignin as a soil builder and source of humic material (22). Lignin is not a fertilizer, but a base exchange material that aids in control of the supply of minerals. It adds humus to the soil, increases porosity, improves drainage, and prevents hard caking of clay soils. It has been found to promote better growth and higher yields.

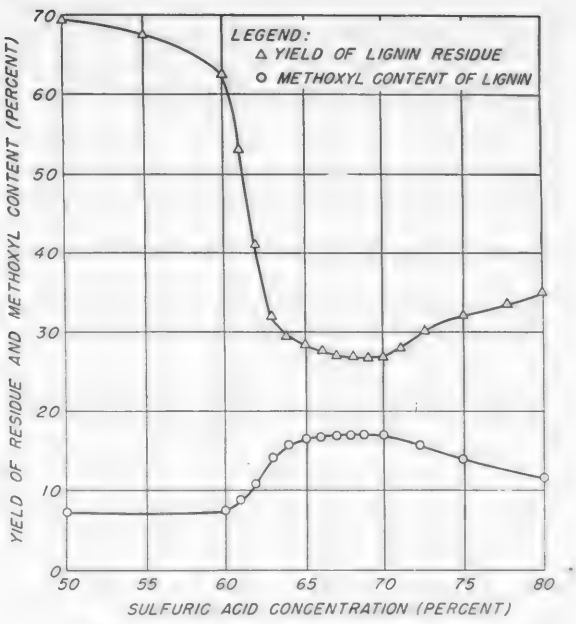

Fig. 1.—Isolation of spruce lignin by sulfuric acid. Time, 16 hours; temperature, 10° C.

Uses developed up to the present time do not use the fundamental chemical properties of lignin and do not represent high enough value to aid in making wood hydrolysis a profitable industry.

Lignin in Logging and Wood Manufacturing Residues

Lignin in whole wood residues has received little attention. Logging wastes remain in the woods and are allowed to rot. This material does not cause stream pollution in the way that spent sulfite pulping liquor does, but it is a fire hazard. The decaying material is host to diseases that may infect the growing trees and it is an economic waste.

Sawmills and lumber millwork plants have large amounts of unused residues in the form of slabs, sawdust, and cull material. A large part of these residues is burned. Some is used for steam and power production, but most is burned in waste burners as a means of disposal.

An economic means of using these residues would aid in timber management, air pollution control, and would remove a serious fire hazard. The carbohydrate portion of logging, sawmill, and millwork residues must compete with carbohydrate byproducts from other agricultural processes, so some high-value use must be found for the lignin in order to provide an economic chemical utilization.

Uses are needed that make use of the fundamental phenolic structure of lignin where it is on its own merit and not in competition with other low-value materials.

Development of high-value uses for lignin has been delayed because the structure of lignin is unknown. Lignin does not split easily into identifiable building units as does cellulose. Because of a lack of an adequate chemical means of identifying lignin, there is no means of determining if lignin as isolated is changed from the way it exists in wood. It has been necessary to seek a satisfactory means for isolating all the lignin in wood in unchanged condition or with the minimum amount of change.

Within the past 25 years, many investigators (23) have made progress in identifying the number and types of reactive groups of lignin, in identifying the cleavage products of lignin, in increasing our knowledge of the chemistry of lignin model compounds, and in developing a proposed structural formula for lignin. This knowledge has made it possible to correlate conflicting ideas about lignin and to carry out a more definite research program. The modes of linkage between the various lignin building units are unknown, and a simple means of cleaving lignin into high yields of its building units remains undeveloped.

The U. S. Forest Products Laboratory has made a number of contributions to the fundamental chemistry of lignin. These will be reviewed in the light of present day concepts concerning lignin.

Except for small amounts of lignin that may be extracted from wood by cold alcohol (24), lignin in wood appears to be attached chemically to the carbohydrates of wood and must be

subjected to a hydrolytic reaction to free the lignin (25). The following hydrolytic agents have been used at the Forest Products Laboratory: sulfuric acid at low temperatures from 0° to 50° C. in concentrations from 50 to 85 per cent; sulfuric acid 0.3 to 5.0 per cent under steam pressures at temperatures from 120° to 250° C.; hydrochloric acid 42 to 45 per cent and dilute at high temperatures; phosphoric acid and other mineral acids; organic acids, such as formic acid, oxalic acid, and acetic acids; mineral acids in organic solutions; pulping chemicals; bases; fungi; and hydrolytic enzymes.

Various concentrations of sulfuric acid from 50 to 85 per cent for periods of time ranging from 1 hour to 16 hours at temperatures from 0° to 50° C. were used to hydrolyze lignocarbohydrate material. Wood meal (60 to 80 mesh) treated with 72 per cent sulfuric acid for 2 hours at 30° C. gave consistent values for lignin (26). These conditions were considered suitable for an analytical method, but the product was dark colored and methoxyl values were low. A series of lignin values under various conditions were determined. A curve for the values for spruce lignin using various concentrations of sulfuric acid for 7 to 16 hours at 10° C. is shown in Fig. 1. Using 70 per cent sulfuric acid at 10° C. for 7 hours, lignin values were the lowest (26.9 per cent cent), and methoxyl content of the spruce lignin was the highest (16.9 to 17.3 per cent). The lignin was a light tan color. Lower concentrations and shorter periods of time did not completely hydrolyze the cellulose; higher concentrations, higher temperatures, and longer periods of time gave insoluble products from the cellulose that increased the lignin residue. Values for maple lignin were shown previously (27). These observations have recently been confirmed by others (28, 23b)) Concentrated hydrochloric acid under controlled conditions gave a similar yield, but the spruce lignin had a methoxyl content of 15.9 to 16 per cent due to the greater ether-cleaving action of hydrogen chloride. Alternate hydrolysis of spruce wood with 1 per cent sulfpric acid on the steam bath and extraction with cuprammonium solution gave a lignin in 24 per cent yield and with 16.9 per cent methoxyl content. Treatment of this lignin with 70 per cent sulfuric acid decreased the yield to 22 per cent with 17.0 to 17.2 per cent methoxyl.

Pretreatment of the wood with dilute acid or alkali or subjecting to extended water extraction removes up to a fourth of the lignin from hardwoods and somewhat less from softwoods (29). Subjecting wood or isolated cellulosic material to heat produces substances that are determined as lignin by sulfuric acid or concentrated hydrochloric acid (30).

Spruce and maple lignins isolated by several methods, including carefully controlled treatment with sulfuric acid, were subjected to several treatments to determine the nature of the reactive groups (31). By the use of different concentrations of alkali for methylation with dimethylsulfate, isolated spruce lignin showed the presence of one strongly acidic phenolic group, one weak phenolic group, and three alcoholic hydroxyl groups in a unit of original lignin molecule with 5 methoxyls (unit weight about 900). The strongly acidic group was methylated in 0.1 to 1 per cent alkali giving a product with 20.9 per cent methoxyl. This group, plus the weakly acidic group, was methylated in 5 per cent alkali, giving a product with 24.1 per cent methoxyl, and all five hydroxyl groups were methylated in 15 per cent alkali, giving a product with 32.2 per cent methoxyl.

The presence of the strong and the weak phenolic groups has been confirmed recently by electrometric titration (32). The two phenolic groups have been confirmed by spectrophotometry (33). The phenolic and alcoholic groups in lignin are bound and not available for methylation in original unhydrolyzed wood. The lack of solubility of carbohydrates in wood in cuprammonium solution and xanthating solutions before hydrolysis or some treatment to bring about cleavage of the lignon-carbohydrate complex indicates the carbohydrates are attached to the lignin.

Diazomethane also reacts with phenolic groups, but because diazomethane reacts with lignin to give nitrogen compounds, its reaction cannot be considered a conclusive test for phenolic hydroxyls (34).

Acetic anhydride, in the presence of pyridine, acetylates both phenolic and alcoholic hydroxyl groups in isolated lignin, giving a light tan product with 14.1 per cent methoxyl and 19.5 per cent acetyl group. This corresponds to 1 acetyl for each methoxyl group. Lignin in original wood does not acetylate in the presence of pyridine but does acetylate in the presence of sulfuric acid to hydrolyze the lignocarbohydrate complex.

Chlorine and bromine react with lignin in varying amounts, depending on conditions. When 1 mole of chlorine for each methoxyl is added to spruce lignin in carbon tetrachloride, approximately 1 chlorine for each methoxyl is introduced in the lignin, giving a product with 16.4 per cent chlorine and 14.0 per cent methoxyl. The nature and stability of the product indicates this chlorine is introduced in the aromatic ring. If more chlorine is introduced, it continues to react, giving products with more chlorine. Methoxyl groups are split off and much of the excess chlorine is given off as hydrochloric acid. It is assumed that the methoxyls are cleaved by hydrolysis but hydroxyl groups are also lost, possibly by loss of water, because it is not possible to methylate to the the same extent as in the original isolated lignin. A product representing rather complete chlorination contained 27.5 per cent chlorine and 6.1 per cent methoxyl. Treatment of this compound with alkali removes about half of the chlorine, and it is assumed that the part removed was on the side chain.

Nitric acid acts on lignin as an oxidizing and as a nitrating agent (35). At room temperature, and with dilute solutions, the action is oxidation and oxalic acid is the principal product (36). At low temperatures and with nitrating mixtures such as fuming nitric acid in acetic anhydride, nitric acid reacts with isolated spruce lignin to give a compound containing 8.8 per cent methoxyl, 16.8 per cent acetyl, and 2.6 per cent nitrogen. The nitrogen content was stable toward hydrolysis that removed the acetyl groups. Reduction with tin and hydrochloric acid gave a product that gave colored compounds by diazotization and coupling with beta naphthol or para nitro analine. This type of reaction with nitric acid is that of substituted phenols and is considered as evidence for an aromatic structure for lignin.

Light absorption by lignin solutions showed the presence of condensed ring structure (37), indicating an aromatic structure and possibly the presence of rings containing oxygen. Spreading measurements of lignin on the surface of liquids showed lignin to be a 3-dimensional molecule. X-ray studies of various isolated lignin samples showed the presence of repeating units in an amorphous lignin (38).

Alcohol Lignin

When extracted wood is heated with an alcohol containing hydrogen chloride, the lignin is cleaved from the carbohydrate. Some of the alcohol group is introduced by transetherification, giving a product containing the alcohol as a substitution on some of the hydroxyl groups. Refluxing of spruce wood with methanol containing 1 per cent hydrochloric acid for 48 hours gave up to 6.7 per cent of a soluble methanol lignin containing 21.4 to 21.5 per cent methoxyl groups. This was found to be a mixture of two lignin derivatives that could be sepa-

rated into two fractions, one with 20.4 per cent and another with 23.6 per cent methoxyl, by pouring the concentrated alcoholic solution into 8 per cent sodium hydroxide (39). A partial separation could also be made by pouring a 20 per cent solution of the methanol lignin in dioxane into about 20 volumes of ethyl ether. The fraction with higher methoxyl content was more soluble in ethyl ether. These products were called methanol lignin.

Methanol lignin is cream colored. It is soluble in acetone, methanol, ethanol, chloroform, dioxane, acetic acid, and glycol ethers. It is not soluble or only slightly soluble in benzene, petroleum ether, and carbon tetrachloride. It may be fractionated into various molecular weight fractions by diluting a chloroform solution of the methanol lignin with carbon tetrachloride. Molecular weights by the "Rast" method ranged from about 10,000 for the least soluble fraction to about 900 for the most soluble. Molecular weights by osmotic pressure and boiling-point raising averaged about 4,000 (40).

The methoxyl groups introduced by methanol and hydrochloric acid are not on the phenolic hydroxyl, because the methanol lignin responds to the same phenolic reactions as insoluble acid lignin. One more methoxyl, for a unit weight of about 900, can be introduced by methylation in $\frac{N}{10}$ alkali with dimethylsulfate on each of the two methanol lignin fractions (41). Complete methylation in 15 per cent sodium hydroxide with dimethysulfate at 20° C. gave a product with 32.0 per cent methoxyl content. The fully methylated product was much less soluble in alkali.

Heating of spruce wood at 65° C. with glycol-monomethyl ether containing 1 per cent hydrochloric acid gave a 22 per cent yield of crude lignin, or about 80 per cent of the lignin in spruce wood at a soluble lignin. This product had 22 per cent alkoxyl calculated as methoxyl. It could be separated into 2 fractions by 8 per cent sodium hydroxide or ethyl ether.

Chlorine reacts with spruce methanol lignin in chloroform, giving a product with 11.8 per cent methoxyl and 26.7 per cent chlorine. After correcting for the chlorine added, it was found that the methanol lignin unit of about 900, that originally had 6 methoxyls, had lost 2 methoxyls during chlorination (41). Since hydrogen chloride is produced during the chlorination, the loss may be due to hydrolysis (42). Some of the chlorine appeared to add to the lignin, indicating the presence of double bonds.

Spruce methanol lignin was reacted with methyl-hypochlorite to determine the presence of double bonds (43). When methanol lignin (methoxyl content, 23.3 per cent) was chlorinated in methanol solution, a product was formed that contained three additional methoxyls for each unit weight of lignin (approximate 900 weight) with 7 methoxyls. Since hydrochloric acid may be produced by the action of chlorine on methanol, the methyl group may be introduced by methanolysis so the chlorination was repeated in the presence of barium carbonate to remove the hydrochloric acid. The reaction was also carried out with methyl hypochlorite in chloroform. In each case, 3 methoxyls were introduced in a unit of 900 weight.

Insoluble acid lignin treated in a similar manner added 3 methoxyls for each 5 methoxyls in the original lignin. This is evidence that units of acid spruce lignin with 5 methoxyls and of methanol lignin with 7 methoxyls contain 3 double bonds. Chlorine in addition to that introduced by addition to double bonds as methyl-hypochlorite was introduced showing that methyl-hypochlorite was also a chlorinating agent.

The groups responsible for some of the unsaturation in lignin have been indicated by the color reactions of lignin. When spruce lignin is treated with a phenol and a strong acid, a colored compound is formed. This color is the same as that produced by coniferyl aldehyde and other compounds with the cinnamic aldehyde grouping (44). One such conjugated unsaturated grouping appears to be present for each 30 methoxyls in spruce lignin. A shift or rearrangement in structure is shown by the change in color in the presence of strong acids (45). A comparison of this color change with that occurring in known compounds indicates the presence of an unsaturated grouping condensed with the 6 position in 4-hydroxy, 3-methoxy phenylpropane unit.

Analysis of the many samples of isolated lignin and lignin derivatives gives an approximate unit formula of $C_9H_7O_{1.6}OH(OCH_3)$ for original spruce lignin. Reactions indicate the presence of an aromatic ring with 3 carbons in the side chain. On the basis of repeating groupings, such as the number of strong phenolic groups, the reacting formula is composed of 5 such groupings and has a molecular weight of about 900. Rast molecular weights give values of that order for the most soluble lignin fractions. Other lignin fractions and other methods for determining molecular weight give multiples of this value.

Hydrogenation of Lignin

Hydrogenation offers another tool for investigating organic compounds. Compounds with unsaturated groups are frequently cleaved at the unsaturated groups. Ether groupings and ether rings are opened while reactive groups are protected.

Preliminary hydrogenations of soluble lignin with platinum at room temperature and low pressure resulted in the absorption of small amounts of hydrogen, but the lignin showed no evidence of being cleaved to smaller molecules.

Soluble lignin in dioxane at 250° to 260° C. in the presence of copper chromium oxide catalyst and 200 to 350 atmospheres of hydrogen was cleaved to methane, methanol, and compounds with 9 carbons (46). When hardwood lignin from aspen was used, over 70 per cent of the products were methanol and p-hydroxy phenylpropane compounds. This high yield of hydroxy-9-carbon compounds indicates that the fundamental building unit of lignin is a 4-hydroxy, 3-methoxy phenylpropane derivative. One of the products has a hyroxy group on the propane side chain, indicating it may have been free or connected as an ether and freed by hydrogenation. Several investigators had previously proposed a $CH_3OC_6C_3$ building unit for lignin, but the hydrogenation experiments gave the first high yield of the C_6C_3 compounds.

Hydrogenation of lignin from other woods yielded similar products (47). Lignin from softwoods was more difficult to hydrogenate, indicating a more complex structure. When wood was hydrongenated at 170° to 200° C. in water, it was converted to a pulp and partially hydrogenated lignin (48). Some of the same 4-hydroxy, 3-methoxy phenylpropane derivatives were produced, indicating lignin in wood containing this building unit.

If hydrogenation of the lignin was carried out in water with nickel as the catalyst, cleavage occurred in the side chain, as well as between the building units, yielding ethylene glycol and diethylene glycol (49). On the basis of a study of the hydrogenation of sugars, the production of glycols indicates the presence of hydroxy groups on the 1 and 2 carbons of the propane side chain. Some of the products retained the methoxy group in the 3-position establishing the relationship to the 4-hydroxy, 3-methoxy phenylpropane building unit.

Soda process lignin recovered from spent pulping liquors was hydrogenated in coal hydrogenation equipment of the U. S. Bureau of Mines at Pittsburgh. Hydrogenation at 300-327° C.

in the presence of copper chromium oxide catalyst gave 69 per cent volatile products and 28 per cent heavy oil. The volatile products were separated into methanol, 8 per cent; water, 14 per cent; and 47 per cent of a mixture of organic substances, including phenols, catechols, hydrocarbons, and oxygen-containing compounds (50).

The use of tin-iodide catalyst and higher temperatures removed more of the oxygen and resulted in greater cleavage of the propyl side chain and higher yields of phenols with methyl and ethyl side chains. The various products isolated represented normal hydrogenolysis products of 4-hydroxy, 3-methoxy phenylpropane derivatives. A low yield of 2, 4-dimethyl phenol indicated that some of the phenyl groups in this alkali lignin were substituted in the 5 position of the building unit.

Lignin residues from the hydrolysis of Douglas-fir sawmill waste were hydrogenated (51). This lignin was more resistant to hydrogenation than methanol lignin or lignin in spruce wood, indicating that polymerization of the lignin had occurred or that decomposed, carbohydrate residues, that retarded hydrogenation, were present. Hydrogenation at 320° C. for 4 to 5 hours caused 1 mole of hydrogen to be absorbed for 32.5 grams of lignin. About one-third of the lignin was recovered apparently unreacted. The part that had reacted was changed largely to hydrocarbons and water.

Products were difficult to isolate in pure form, but most of those identified were normal hydrogenolysis products of 4-hydroxy, 3-methoxy phenylpropane. An exception was the presence of naphthalene, dibenzyl, and diphenyl. These products, or the compounds responsible for them, may have been formed by condensation in the presence of acid during wood hydrolysis.

Cleavage of lignin from hydrolysis of Douglas-fir by heat in the absence of hydrogen (52) gave 55 to 66 per cent of a char and 5.2 to 8.9 per cent of a settle dtar. The tar was separated and found to consist of phenols, methoxy-phenols, catechols, oxygen-containing compounds, and hydrocarbons of the type that would be derived from 4-hydroxy, 3-methoxy phenylpropane derivatives. Some of the products retained the methoxy group in the 3 position. Some of the propane side chains had been cleaved so the products contained propyl, ethyl, methyl, and no side chain. A small amount of material contained alkyl substitution ortho to the phenolic hydroxyl showing the presence of 5 substitution of the 4-hydroxy, 3-methoxy phenylpropane unit.

The various products from hydrogenation, pyrolysis, alkali fusion, and oxidation refer to the same fundamental building unit. There is no certainty of the manner by which these units are linked together. The isolation of dimers of the building unit and establishment of the position of linkage appears to be the next step in a better understanding of lignin. When the position and mode of linkage is determined, a more direct approach to a means of converting lignin into high-value products directly related to its structure should follow soon.

Literature Cited

1. Lewis, H. F. 1945. Lignin, an economic liability or chemical asset. *Chem. Eng. News* 23:1074.
2. Anon. 1947. Wood waste in the United States. U. S. Dept. of Agriculture, Forest Service, Report 4.
3. Hatch, R. S. 1947. Magnesia base pulping. *Pulp and Paper Mag. of Can.* 48 (13):85.
4. Piette, G. and Demers, G. 1945. Lignin extract as a stabilizing agent for road foundations. *Roads and Bridges* 83(9): 70–73, 114–118.
   Anon. 1954. Semichemical pulp waste makes road binder. Staff Report, *Chem. Eng.* 61(11):140.
   Wiley, A. J., Sherman, W., Bableck, G., Rice, N., Dickerman, G. K., and Collet, G. 1953. Use of spent liquor in reconditioning asphalt road surfaces. *Tappi* 36(4):162.
   Sherman, W. A. 1950. Spent waste liquor as road binder. *Paper Trade J.* 131:15.
5. Anon. May 1, 1955. Once wasted sulfite liquor, now an excellent road binder. U. P. Report, *Wisconsin State Journal,* Madison.
6. Anon. 1953. Evaporated pulp spent liquors. Staff Report, *Chem. Eng.* 60 (4):122.
7. Anon. Aug. 7, 1939. Lignin. Marathon Paper Mills Co. Chemical Products Div., *Bulletin.*
8. Anon. 1954. Calcium lignin sulfonate. *Chem. News* 32:1072.
9. Johnson, A. Margaret and Marshall, H. B. 1949. Lignin sulfonic acid as a tanning agent. *Pulp and Paper Mag. of Can.* 50(8):98.
   Buchanan, M. A., Lollar, R. M., and Niemeyer, D. D. 1947. Tanning properties of lignosulfonates. *Paper Trade J.* 124:18.
   Maeda, Hirokuni. 1942. Lignosulfonic acid. *J. Soc. Chem. Ind. Japan* 45:267.
10. Nilsson, G. 1950. Precipitation of protein from whey. *Kg. Lantbrucks Hogskol Ann.* 17:1–5.
11. Prichard, W. C. and Daily, R. A. 1943. Extraction of substantially pure lignosulfonic acid from waste sulfite liquor. U. S. Pat. 2,325,524.
12. Marshall, H. B. 1952. Utilization of waste sulfite liquor. *Pulp and Paper Mag. of Can.* 53(4):125.
13. Sanky, C. and Marshall, H. B. 1949. Separation of vanillin from alkaline solution. U. S. Pat. 2,489,200.
14. Anon. 1951. Indulin kraft lignin from pine wood. W. Va. Pulp and Paper Co., Charleston, S. C. Bull. L–6.
    Anon. 1954. Indulin, the ABC of Indulin. W. Va. Pulp and Paper Co., Charleston, S. C. Tech. Bull. 108.
15. Meadol, Lignin from hardwood. Mead Corp., Chillicothe, Ohio.
    Pallack, A., Keilen, J. J., Jr., and Drum, L. F. Recovery of lignin from concentrated black liquor. U. S. Pat. 2,464,828.
    Keilen, J. J. 1955. Alkali lignin. A tree crop product making good. *Chemurgic Digest* 14(3):13.
    Brookbank, E. B. 1946. Industrial uses of alkali lignin. *Paper Trade J.* 122 (13):44.
    Anon. 1954. Lignin—perpetual source of chemical. *Chem. Eng.* 61:144.
16. Zimmermann, F. J. 1954. Destructive oxidation of organic matter in wastewater disposal. U. S. Pat. 2,665,249.
17. Anon. 1942. A new wood sugar process. *O, Anti-wuorinen Chem. Tech.* 15 (24):253.
    Scholler, H. 1939. Saccharification of wood with dilute acid under pressure. *Chim. Ind. Agr. Biol.* 15:195.
    Harris, E. E. and Beglinger, E. 1946. Madison wood-sugar process. *Ind. Eng. Chem.* 38:890.
18. Bergius, F. 1937. Conversion of wood to carbohydrates. *Ind. Eng. Chem.* 29: 247.
    Fredenhagen, K. and Cadenbach, G. 1933. Wood saccharification by concentrated hydrofluoric acid. *Angew. Chem.* 46:113–117.
19. Karsch, W. 1942. Making alkali-soluble lignin. Ger. Pat. 729,344.
    Grasser, G. 1942. Conversion of lignin from saccharification of wood into water-soluble lignin. Ger. Pat. 729,343.
    Kast and Ehinger. 1943. Reactive lignin from lignin by saccharification of wood. g.m.bh. Chem. Fab. Belg. Pat. 448,826.
    Kippham, K. 1949. Wood saccharification lignin as raw material for resins. *Kunstoffe Bd.* 39(3):71.
20. Farber, E. Lignin resin. U. S. Pat. 2,443,576.
    Lautsch, W. 1944. Lignin LX, lignin-base-ion exchangers. *Die Chemie* 57: 149.
    Gault, H. and Hiong, K. W. 1945. Purification of hard waters by means of technical lignin. *Compt. rend.* 220:608.
21. Englert, R. D. and Friedman, L. 1945. Testing plastics of Scholler lignin. *Pacific Plastics Mag.* 3(10):38, 40.
22. Anon. 1945. Lignin useful in raising potatoes. *Paper Mill News* 68(45):7.
    Dunn, S., Seiberlich, J., and Eppelheimer, D. E. 1945. Use of lignin in potato fertilizers. N. E. Wood Utilization Council. Bull. 7:21–24.
    Aries, R. S. 1946. Lignin as a fertilizer material. *Paper Trade J.* 123(21):47.
    Anon. 1950–51. Lignin for better crops. Yearbook of Agriculture, U. S. D. A., p. 883.
23. a. Leopald, B. 1954. Recent lignin research in Sweden. *Pulp and Paper Mag. of Can.* 55(3):184.
    b. Wacek, A., Zeisler, S., and Reigelmeyer, P. 1954. Methoxy content of spruce wood. *Monatsh* 85(3):33.
    c. Higuchi, T., Kawamura, I., Morimoto, L., and Kanda, T. 1954. Formation of lignin in bamboo shoots. *J. Jap. For. Soc.* 36(4):131
    d. Baruns, F. E. 1939, 1940. Native lignin. *J. Am. Chem. Soc.* 61:2120. *Paper Trade J.* 111(14):33.
    e. Hibbert, H. and coworkers. 1939, 1943, 1944. Studies on lignin and related compounds. *J. Am. Chem. Soc.* 61:509, 516, 2190, 65:1170, 1862; 66:604, 607.
    f. Freudenbreg, K., Lautsch, W., and Engler, K. 1940. Formation of vanillin from spruce lignin. *Chem. Ber.* 73B. 167.
    g. Kratzl, K. 1943. Synthesis of model substances for lignin sulfonic acid. *Chem. Ber.* 76B. 895.

Freudenberg, K. and Richtzenhain, H. 1943. Enzyme experiments on formation of lignin. *Chem. Ber.* 76B. 997.

Bland, D. E., Ho, G., and Cohen, W. E. 1949. Aromatic aldehydes from the oxidation of some Australian woods and their chromatographic separation. *Aus. J. Sci. Res.* 3(4):642.

24. Harris, E. E. 1940. Utilization of waste lignin. *Ind. Eng. Chem.* 32:1049.
25. Harris, E. E. 1953. A lignin-carbohydrate bond in wood. *Tappi* 36(9):402.
26. Ritter, G. J., Seborg, R. M., and Mitchell, R. L. 1932. Factors affecting quantitative determination of lignin by 72 per cent sulfuric acid method. *Ind. Eng. Chem.* (Anal. Ed.) 4:202.
27. Sherrard, E. C. and Harris, E. E. 1932. Factors influencing properties of isolated wood lignin. *Ind. Eng. Chem.* 24:103.
28. Adams, G. A. and Castagne, A. E. 1949. Determination of lignin in cereal straws. *Can. J. Res.* 27B:915
29. Harris, E. E. 1953. The effect of alkali treatment on the yield of lignin. *Ind. Eng. Chem.* (Anal. Ed.) 5:105.
Ritter, G. J. and Barbour, J. H., 1935. The effect of pretreatments of wood on the lignin determination. *Ind. Eng. Chem.* (Anal. Ed.) 7:238.
Cohen, W. E. and Harris, E. E. 1937. Pretreatment of wood with hot dilute acid and its effect on lignin values. *Ind. Eng. Chem.* (Anal. Ed.) 9:234.
Harris, E. E. and Mitchell, R. L. 1939. Effect of various pretreatments on the lignin determination of wood. *Ind. Eng. Chem.* (Anal. Ed.) 11:153.
30. Hawley, L. F. and Wiertelak, J. 1931. Effect of mild heat treatment on the chemical composition. *Ind. Eng. Chem.* 23:184.
Hawley, L. F. and Harris, E. E. 1932. Synthetic lignin. *Ind. Eng. Chem.* 24: 873.
Harris, E. E. 1936. Effect of mild heat treatments on wood carbohydrates. Cellulose Div., Am. Chem. Soc. Kansas City.
31. Harris, E. E., Sherrard, E. C., and Mitchell, R. L. 1934. Some chemical reactions of maple and spruce lignin. *J. Am. Chem. Soc.* 56:889.
32. Sarkanen, K. and Schuerch, C. 1955. Conductometric determination of phenolic groups in mixtures such as isolated lignins. Cellulose Div., Am. Chem. Soc.
33. Goldschmid, O. 1954 Determination of phenolic hydroxyl content of lignin. *Anal. Chem.* 26:1421.
34. Spencer, E. Y. and Wright, G. F. 1941. Action of diazomethane on lactones and on lignin. *J. Am. Chem. Soc.* 63:2017.
Kratzl, K. and Wittmann, E. 1954. Reaction of diazomethane with α, β, unsaturated aldehydes. *Monatsh* 85(1):7.
35. Harris, E. E. and Sherrard, E. C. 1936. Action of nitric acid on lignin. Cellulose Div., Am. Chem. Soc., Pittsburgh.
36. Harris, E. E. 1948. Alcohol from Douglas-fir wood waste utilization of lignin. *Timberman* 49(4):67.
37. Stamm, A. J., Harris, E. E., and Semb. J. 1932. Absorption spectra of lignin solutions. *J. Phys. Chem.* 36:1574.
38. Harris, E. E., Parker, E. A., Sherrard, E. C., and Clark, G. L. 1938. X-ray study of lignin. *Biodynamica* 31:1.
39. Harris, E. E. 1936. Fractionation of methanol lignin. Cellulose Div., Am. Chem. Soc., Pittsburgh.
40. Loughborough, L. L. and Stamm, A. J. 1936. Measurement of properties of lignin solutions from viscosity, osmotic pressure, boiling point raising, diffusion, and spreading measurements. *J. Phys. Chem.* 40:1113.
41. Harris, E. E. 1936. Some characteristics of wood lignin. *J. Am. Chem. Soc.* 58:849.
42. Ghaswalla, R. P. and Donnan, F. G. 1936. The reaction kinetics of acid hydrolysis of phenolic ethers. *J. Chem. Soc.* 1341–46.
43. Harris, E. E. and Lofdahl, L. J. 1941. Reaction of methyl hypochlorite with lignin. *J. Am. Chem. Soc.* 63:112.
44. Pew, J. C. 1951. Structural aspects of color reactions of lignin with phenols. *J. Am. Chem. Soc.* 73:1678.
45. Pew, J. C. 1952. Structural aspects of color reactions of lignin with strong acids. *J. Am. Chem. Soc.* 74:2850.
Pew, J. C. 1952. Color reactions of lignin in solution compared to similar reactions in the solid state. *J. Am. Chem. Soc.* 74:5784.
46. Harris, E. E., D'Ianni, J., and Adkins, H. 1938. Reactions lignins with hydrogen. *J. Am. Chem. Soc.* 60:1467.
47. Harris, E. E. and Adkins, H. 1938. Reactions of lignin with hydrogen. *Paper Trade J.* 107:38.
48. Harris, E. E. 1940. Hydrogenation of lignin. *Paper Trade J.* 111:27.
Harris, E. E. and Sherrard, E. C. 1939. Simultaneous production of wood pulp and the conversion of the noncellulosic constituents of wood to alcohols, oils, and resins. Cellulose Div., Am. Chem. Soc., Boston. U. S. Forest Products Lab Mimeo R–1218.
49. Saeman, J. F. and Harris, E. E. 1946. Hydrogenation of lignin over raney nickel. *J. Am. Chem. Soc.* 68:2507.
50. Harris, E. E., Saeman, J. F., and Bergstrom, C. B. 1949. Lignin hydrogenation products. *Ind. Eng. Chem.* 41:2063.
51. Clark, I. T., Hicks, J. R., and Harris, E. E. 1951. Hydrogenation of Douglas-fir lignin. *Tappi* 34:6.
52. Fletcher, T. L. and Harris, E. E. 1947. Destructive distillation of Douglas-fir lignin. *J. Am. Chem. Soc.* 69:3144.
Fletcher, T. L. and Harris, E. E. 1953. Products from the destructive distillation of Douglas-fir lignin. *Tappi* 35: 402.

Discussion

Eric A. Anderson (State U. of N. Y. College of Forestry): Have you any information to disclose on hydrogenation of lignin?

Dr. Locke: We have done some work on this. Some of this work is described in the part of the paper I had to omit because of the shortage of time. Depending on conditions, phenols, cyclohexanols, or hydrocarbons are formed by hydrogenation. The products also depend on the previous history of the lignin and its origin. The research is still in fundamental stages. It is hoped that a better knowledge of the structure of lignin will give leads that will make it possible to obtain high yields of desired compounds.

Dr. Jean Mater (Mater Engineering): Are you doing any research specifically aimed at developing lignin-aldehyde resins for use as composition board and plywood adhesives?

Dr. Locke: Considerable work was done several years ago using formaldehyde and also furfural. These appeared to have some value as extenders of phenolic resins but were brittle when used alone. It is believed that less degraded lignins may have a better future than those that have been available. Some preliminary work has been done on condensible tannins also.

Reavis C. Sproull (Herty Foundation): What chemical structure typifies the skeletal structure of lignin from a variety of wood species?

Dr. Locke: 4-hydroxy-3 methoxyphenyl propane derivatives are the building blocks of lignin, but how it is put together is unknown. This is discussed briefly in the part of the paper not read and more fully in a report on lignin appearing in the February 1955 number of F.P.R.S. Journal. One of the difficulties of the past has been the possibility of changes occurring during isolation. Pew, of the Forest Products Laboratory, is attempting to isolate lignin by an enzymatic method which seems to have promise of giving an unchanged lignin.

J. P. Krier (Montana State U.): "Reclaimix" is a paper mill residual being used for reclaiming old macadam road material for re-use. Is this a lignin product?

Dr. Locke: I am not familiar with the product. However, concentrated spent sulfite pulping liquor has been used for that purpose.

Whole Wood as a Potential Source for Shaped Articles[1]

A. K. ESTERER

Chief of Technical Planning, Development Center, Weyerhaeuser Timber Co., Longview, Washington

Discusses commercial importance of a potential process for manufacturing shaped articles from whole wood substance. Review of recent literature points to the conclusion that a reforming of whole wood under heat and pressure is accomplished by a reconstitution of fragments cleaved from whole wood at various temperatures.

Introduction

THE COMMERCIAL IMPORTANCE of shaped articles of all kinds is evident from the fact that in 1954 a total of 970 million pounds of plastics (240 million lbs. thermosetting, 730 million lbs. thermoplastic) were produced (1).

Wood, being a compounded structural material which has some plastic properties when subjected to conditions of heat and pressure, might fill a share of this demand. Wood is pricewise competitive but in general, quality and properties of the wood plastics, i.e., plastics in which wood is the only reactive constituent, have not met standards set by other materials. It seems, therefore, that the basic behavior of wood substance under heat and pressure requires a better understanding.

In order to define the work field, it should be recalled that this naturally replenishable raw material, wood, can be utilized along three broad avenues (2): as wood, as fiber, and as a chemical raw material.

In the first category, there are three major avenues—the use of wood in the form of:

Lumber—for primary structures,
Particles—for secondary structures (boards, tiles),
Particles—for shaped articles.

This review deals with the last approach, i.e., the shaping or reforming of wood substance under heat and pressure excluding added binders. The term "reforming" refers to a reassembly of wood constituents and secondary products split off and formed during the treatment; it does not refer to a rebuilding of lumber. This review presents the recent progress and is limited, somewhat arbitrarily, to the last five years.

Complex Problem

The problem of reforming of wood is a complex one. The problem will be broken down, therefore, into simple components, each analyzed and an attempt made to combine the conclusions obtained. The procedure will be to consider separately the effect of pressure on wood, the effect of temperature on wood, the effects of pressure and temperature combined, and the effect of added catalysts.

The effects of temperature and pressure are represented in Fig. 1, which shall be used as a guide for showing status and progress made during recent years.

Summary of Status

The status of knowledge of the effect of heat and pressure on wood as of several years ago has been summarized by Stamm and Harris (3). Briefly, it is stated that the effect of heat on soft- or hardwood results in: (a) a weight loss, which increases with time, (b) an increase of the lignin content, and (c) a decrease of Cross and Bevan cellulose.

The fiber-to-fiber bond of cellulosic fibers in paper or board is not fully clarified, but is recognized as probably caused by surface forces during drying. In Masonite fiber boards, the binding is caused by the natural binder, lignin, after it has been activated; activation can be aided by the use of chemicals acting as catalysts.

It was further recognized that flow of lignin in wood is increased by application of pressure and by the presence of water, which acts as a plasticizer.

Effect of Pressure

The action of pressure on wood has shown that unheated wood is a plastic material because of a hysteresis in the stress-strain curves. Perhaps it is safer to express this negatively, i.e., wood is not a perfectly elastic compound, but it is also not a readily flowing plastic. The plastic properties of wood have not been studied systematically with the objective of elucidating its rheological behavior (4).

The effect of stress on wood seems to be entirely mechanical, and becomes evident as a weakening of wood. A weakening effect is introduced when unheated wood is bent to a radius less than approximately 320 times its thickness (5). Application of pressure compresses the fibers or tracheids into S-shapes. Examination of the microcompression lines shows a parting of the bundles of microfibrils. Since the microcompression lines occur at lower stresses (approximately 5000 psi) than the macrocompression lines, the lateral cohesion of the microfibrils in the tracheids must be less than the strength of the middle lamella by which the tracheids are cemented (6,7,8).

There is some evidence that high pressures cause bonding of cellulosic fibers. This has been suggested as a means of increasing dimensional stability of paper made from wood cellulose (9).

Effect of Temperature

The effect of temperature on wood substance is complex and profound. This review will consider only temperatures below the exothermic pyrolytic cleavage of wood, i.e., the complete destruction of wood, which is placed at about 400–475° F.

Exploration of the effect of a mild heat treatment on wood was undertaken for the first time in 1931 (10). Such a treatment seemed to offer the possibility of making wood dimensionally stable by removal of water of constitution and formation of ether cross-linkages. However, it has now been established that the removal of water does not result in formation of ether-type cross-linkages (11).

Understanding of the effect of temperature on the cleavage of wood was advanced by stepwise heat treatment of oak sapwood and measuring C-H-O distribution in the residues (12). At 221° F., in a current of dry nitrogen, the first major products of decomposition are not water but probably glyoxal

[1] Presented at Session VI, Chemical Utilization, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

The Author: A. K. Esterer holds Ph.D. degree from the U. of Munich, Germany. He has been engaged in studies of utilization of wood waste for the Weyerhaeuser Timber Co. since 1944. Dr. Esterer's industrial background includes the manufacturing fields of dissolving pulps, viscose rayon, and coal carbonization.

and glycol-aldehyde. Between 275 and 300° F., formaldehyde is cleaved off. At 420° F., acrid fumes are given off with accompanying brown discoloration of the wood. Substantial quantities of water and oxygen are evolved at about 465° F., in a ratio which points to a cleavage of hydroxyl groups.

The cleavage into thermolabile aldehydes in the initial steps, followed by the formation of water from cleavage of hydroxyl groups, is consistent with the observation that the decomposition of wood at temperatures below the pyrolytic decomposition is endothermic, becoming exothermic at about 480° F.

A study of reaction kinetics over a wide range of temperatures confirmed that hemicelluloses are the most sensitive constituent of wood and probably are the source of the initial products of decomposition (13). When isolated, they degrade four times as fast as wood or isolated alpha cellulose. It was further shown that:

(1) Thermal degradation of wood varies with the heating conditions and involves a combination of hydrolysis and oxidation.
(2) Thermal degradation is greater in the presence of air than when it is absent, because of oxidative effects of atmospheric oxygen.
(3) Thermal degradation is greater in closed systems because of hydrolysis caused by built-up acid concentration (13, 14).
(4) Thermal degradation follows a first order reaction; the rate is probably determined by the diffusion of the reaction products.

Thermal stability of wood substance is also dependent upon its moisture content. At constant temperature, strength decreases and discoloration increases with increasing moisture content (15, 16). However, if the relative humidity of the environment is kept at 25 per cent, which is necessary for vapor diffusion, lumber can be dried rapidly without degradation at relatively high temperatures, 284° F. (17). A heat treatment of fiber board (280–350° F.) shows an initial increase of strength properties, presumably caused by completion of bonding reactions, followed by a decline of strength (18).

Effect of Heat and Pressure

When pressure and temperature are combined, novel effects take place because during heating wood gradually liberates reaction products which can be made to react with each other or

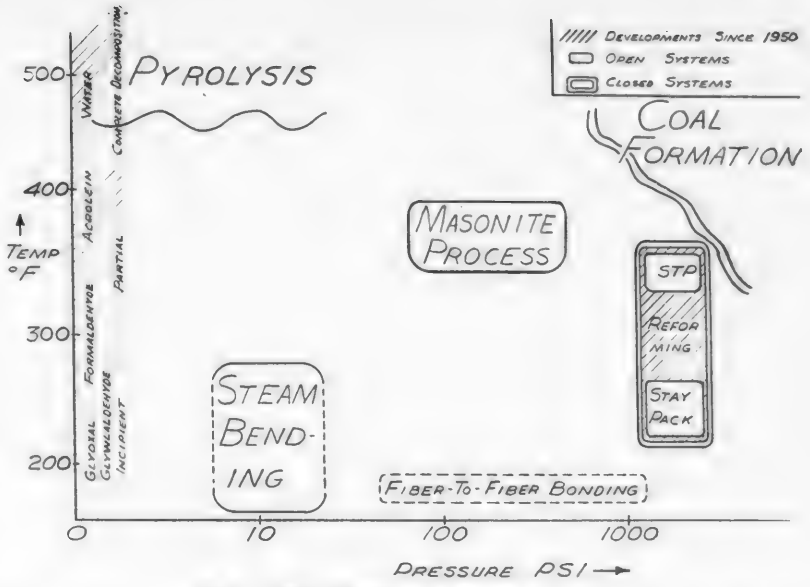

Fig. 1.—Effect of heat and pressure on wood.

with the residue to form new products. The first and basic reaction is a partial hydrolysis of wood, in particular hemicelluloses, which has received considerable attention in the past and has been reviewed recently (19).

Because wood evolves gaseous products when heated, the difference between open systems and closed systems must be considered.

Open Systems: In open systems, the effect of volatile products of decomposition and of water on solid products is difficult to control. This effect probably is relatively small because the active volatile products are permitted to escape except for a few localized spots where they are trapped and their concentration is temporarily increased. Reaction with products of decomposition can occur but must necessarily be incomplete. The effect of pressure, therefore, lies in the direction of improved heat transfer and fiber-to-fiber bonding.

Bonding between cellulose fibers may be introduced at high pressures (9, 20, 21). This might explain the statement that acceptable hardboard can be manufactured from wood fiber without addition of binder (22). This confirmed the careful investigation of the effects of temperature and pressure on hardboard quality, which showed that in wet formed mats density is the strength-determining parameter and density is governed by the pressure applied (23).

Bonding is probably effected by the products which are formed up to 400° F., including lignin (19). The possibility that lignin is activated under conditions prevailing in the defibrator or in the Masonite process had been pointed out. It was made more probable by the finding that the carbohydrate portion in wood exerts a protective action on lignin and that, under hydrolytic conditions, this protective action is removed (24, 25).

An additional bonding effect can be obtained by cross-linking with sulfur (26).

Closed Systems: When working in a closed system, wood can be "reformed", i.e., the cleavage products can be recombined quantitatively. Such systems offer a better control than open systems but introduce another variable, the volume. The latter, when large, dilutes the concentration of reactive products. The most efficient process is, therefore, one which operates at minimum volume.

Such a process has been studied extensively (27, 28), employing a self-sealing mold by which a perfect material balance, including water, was obtained. Careful experimentation, using air-dry sawdust from beech *(F. silvatica)* and European spruce *(P. excelsa,)* and systematically varying moisture content of sawdust, pressure, temperature, and duration, has shown that resinification occurs, probably by a combination of several reactions which are known as such. These can be arranged in three different series of reactions (29): (a) hemicelluloses-furfural-furfural resins, or succindialdehyde; (b) hexosans-hydroxymethyl-furfural-levulinic acid-(+ furfural)-acetoxy courmarone-courmarone resin; (c) lignin-(hydrolysis) activated lignin-condensation (with aldehydes).

Several aldehydes are formed during the depolymerization of lignocellulose, such as formaldehyde, furfural, and succindialdehyde. Formic acid which can serve as catalyst is liberated in series (a) and (b). These chain reactions consolidate and amplify previous knowledge.

The importance of the presence of water is demonstrated. Although it was known that water acts as a plasticizer in the heat-pressing of wood, it is now recognized that the actual mechanism of the participation of water in the reforming of wood is a much more complex one, water appearing in the dual role of hydrolysis agent and product of condensation. Five to 12 per cent water has to be present in order to start hydrolysis of hemicellulose. The initial hydrolysis is probably catalyzed by acetic acid liberated from acetylxylan.

This concept was confirmed by isolation and identification of intermediate products.

Processing conditions employed in the laboratory were as follows, using a test piece 0.5 x 4.7 x 12.8 inches:

Cold prepress—1200 psi
2 Mins. to reaction pressure—2500 psi
6 Mins. to reaction temperature—356° F.
4 Mins. at reaction temperature
5 Mins. cool

17 Mins. total reaction time

Under these conditions, a M.R. of 8800 psi and a water absorption as low as 8.8% have been obtained at 87 lbs./cu. ft. It was further demonstrated that hemicelluloses determine strength characteristics and lignin determines flow and resistance to water absorption. Beechwood, an example of a typical hardwood, containing approximately 20 per cent hemicelluloses, yields products which have stronger mechanical properties than those from sprucewood, which contains approximately 10 per cent hemicelluloses.

All products, so far, are dark colored, which limits their use to articles in which color is not important.

Based on laboratory data, a process has been commercialized which produces shaped articles such as toilet seat rings from sawdust without addition of binder (30).

Addition of Catalysts

The fact that the first stage of cleavage of wood is a hydrolysis has led to attempts to catalyze this step by addition of small amounts of mineral acids or acid salts, with the result that reaction temperatures can be lowered considerably. Several patents have been issued which cover the addition of mineral acids, or acid salts (31, 32, 33). A summary of resulting condensation and hydration reactions is available (34). As yet, no attempt seems to have been made to catalyze specific reactions in order to improve selected product qualities.

Conclusion

Although wood is designed and built by nature as a structural material, it can be reformed to produce new articles of use. The last five years appear to have been particularly successful in clarifying the complex reactions which occur when wood is heated under pressure, showing conditions under which these reactions can be utilized to produce shaped articles from reformed wood. Further developments might consider the promotion of selected reactions so that processing costs can be reduced and product quality is improved.

Literature Cited

1. Anon. 1955. Trends in the plastics industry. Modern Plastics 32 (5): 68.
2. Heritage, C. C. 1952. The role of wood in industry. Proc. of Wood Symposium, Timber Engineering Co. pp. 36-42.
3. Stamm, A. J. and Harris, E. E. 1953. Chemical processing of wood. Chemical Publishing Co., Inc., New York. pp. 81-2, 271-2, 290-2, 350, 360-2.
4. Meredith, R. 1953. Mechanical properties of wood and paper. Interscience Publishers, New York.
5. Wangaard, F. F. 1952. The steam bending of beech. Jour. FPRS II (4): 35-41.
6. Frey-Wyssling, A. 1953. The structure of compression lines in stressed wood. Holz Roh-u Werkst. 11:283-8; CA 47: 11724.
7. Kisser, J. and Steininger, A. 1952, 1953. Macroscopic and microscopic structure changes on bending wood. Holz Roh-u Werkst. 10:415; CA 47: 2982.
8. Ivanov, Yu M. 1953, 1955. Changes in the microscopic structure of wood during deformation and rupture. Trudy Inst. Lesa Akad. Nauk. SSSR. 9:89-114; CA 49: 4287.
9. Lorey, F. W. and Libby, C. E. 1954. Methods for dimensionally stabilizing paper. TAPPI 37: 321-31.
10. Hawley, L. F. and Wiertelak, J. 1931. Effect of mild heat treatment on the chemical composition of wood. Ind. Eng. Chem. 23: 184-6.
11. Seborg, R. M., Tarkow, H., and Stamm, A. J. 1953. Effect of heat upon the dimensional stability of wood. Jour. FPRS III (3): 59-67.
12. Gillet, A. and Urlings, J. 1952. Comparative pyrolysis of wood, cellulose, lignin and coal. I. Stepwise pyrolysis of wood. Chim. et Ind. 67: 909-19. CA 46: 9829.
13. Stamm, A. J. 1955. Thermal degradation of wood and cellulose. Abstracts of Papers, 127th ACS Meeting, p. 7E.
14. Mitchell, R. L., Seborg, R. M., and Millett, M. A. 1953. Effect of heat on the properties and chemical composition of Douglas-fir wood and its major components. Jour. FPRS III (4): 38-42.
15. Kollmann, F., Keylwerth, R., and Kubler, H. 1951, 1952. Discoloration of whole wood and veneer during commercial wood drying. Holz Roh-u Werkst. 9: 382: CA 46: 2292.
16. Kollman, F. 1952. The effect of temperature on the elasticity and strength of wood. Holz Roh-u Werkst. 10: 269; CA 46: 11677.
17. Czepek, R. 1952. Theory and practice of high-temperature wood drying. Holz Roh-u Werkst. 10: 1; CA 46: 5288.
18. Voss, K. 1952, 1953. Heat treatment of wood fiber hardboards. Holz Roh-u Werkst. 10: 299; CA 47: 316.
19. Runkel, R. O. H. 1951. The thermoplastic behavior of wood, I. Holz Roh-u Werkst. 9: 41-55.
20. Centola, G. and Pancirolli, F. 1950. Investigations on the preparation of fiber boards. Ind. Carta (Rome) 4(4): 39-43; CA 44: 9148.
21. Forman, L. V. 1950. Fibre-to-fibre bonding. Pulp & Paper Mag. of Can. 51 (10): 109-14; TAPPI 33: 444-50.
22. Schwartz, S. L. and Baird, P. K. 1950. Effect of molding temperature on the strength and dimensional stability of hardboards from fiberized, water-soaked Douglas-fir chips. FPRS Proc. 4:322-6.
23. Turner, H. D., Hohf, J. P., and Schwartz, S. L. 1948. Effect of some manufacturing variables on the properties of fiberboard prepared from milled Douglas-fir. FPRS Proc. 2:100-12.
24. Kratzl, K. 1952. Thermal treatment of wood with water. Mtt. Osterr. Ges. Holzf. 4: 45; CA 46: 9298.
25. Kratzl, K. and Silbernagel, H. 1952, 1953. Thermal treatment of spruce and lignin with water. Monatsh. 83: 1022-37; CA 47: 1382.
26. Smith, W. R., Mellenger, E. R., and Othmer, D. F. 1951. U. S. Patent 2,552,597.
27. Runkel, R. O. H. and Wilke, K D. 1951. The thermoplastic behavior of wood, II. Holz Roh-u Werkst. 9: 260-70; CA 45: 9855.
28. Runkel, R. O. H. and Witt, H. 1953, 1954. The thermosplastic behavior of wood, III. The water and alcohol-soluble components in heat-plasticized wood. The result of a paper chromatographic investigation. Holz Roh-u Werkst. 11: 457-61; CA 48: 6117.
29. Runkel, R. O. H. 1951. Wood plasticization. Das Papier 5: 3-12; CA 45: 4037.
30. Runkel, R. O. H. 1950. German Patent 841,055.
31. Glaubert, S. 1952. U. S. Patent 2,587,-992.
32. Willey, G. S., and Ruthman, K. S. 1950. U. S. Patent 2,495,043.
33. Othmer, D. F. and Ricciardi, L. G. 1950. Wallboard from wood waste without resins by a dry process. N. E. Wood Util. Council Bull. 31, pp. 59-77.
34. Farber, E. 1952. Condensation and hydration reactions with low grade cellulosic materials. TAPPI 35 (1): suppl. pp. 204.

Discussion

K. G. Chesley (Crossett Lbr. Co.): How can lignin be activated under conditions prevailing in the defibrator?

Mr. Esterer: This refers to a partial hydrolysis which can occur in the defibrator. The hydrolysis splits some of the carbohydrate-lignin linkages and liberates a reactive lignin. The hydrolysis is catalyzed by organic acids liberated during the defibration step.

H. D. Erickson (U. of Washington): Can you give some technical data relative to production and manufacturing costs of the Runkel toilet seats?

Mr. Esterer: The seats are produced in a plant operated by Ohlemeier Bros. in West Germany. Production is approximately 1300 complete seats per day. They are manufactured from waste beechwood in three presses, each having six openings. The seats are available as pro-

duced or coated with pigmented lacquers. The seats retail from $1.75 for the ring without cover, not coated, to $4.00 for a white seat with cover. Manufacturing costs are estimated at 50 per cent of the retail price. The seats are selling so well that a second plant is under construction. A few cross-sectional samples are displayed here for inspection.

T. T. Roubicek (Canadian Forest Products Ltd.): What is the difference between Staypack and reformed wood?

Mr. Esterer: They differ with respect to raw material and end product. Staypack is manufactured from selected and preshaped wood which involves trim loss, and limits the final shape. Reported press cycles are long, e.g., 85 minutes for 7/8-inch Staypack. Reformed wood is made from residuals, involves no trim loss, and has considerably wider latitude as to product shape. The underlying mechanism appears to be the same, although it was previously believed that the bonding of Staypack was caused by a slight flow of lignin at elevated temperature and pressure, and that the lignin was plasticized by water. Probably both processes will be able to co-exist—the Staypack process for upgrading veneers, the Reforming process for manufacture of articles of use from residuals.

F. H. Snyder (Consultant): What pressures are used in molding?

Mr. Esterer: Between 1200 and 2500 lbs. per square inch.

Shrinkage of Red Oak and Beech[1]

D. C. McINTOSH[2]

An equation was derived to determine the value of the radial shrinkage of "rayless" wood of both red oak and beech. Results of tests to determine the longitudinal and tangential shrinkage of broad rays are given. Experimental measurement data show the radial and tangential shrinkage of springwood and summerwood of red oak and beech.

Introduction

THE EFFECT OF RAYS in restricting the radial shrinkage of wood of red oak and beech was discussed by the author in recent reports (1, 2).[3] The studies showed (1) that broad rays of red oak shrank only about one-half as much in the radial direction as did the wood (including fine rays) adjacent to them. It was also shown that transverse sections of beech, free from the influence of broad rays, shrank radially about 3 times as much as did the broad rays (2). Distortion during the drying of transverse sections of both species substantiated the results with regard to the difference in radial shrinkage and indicated the influence of rays on the anisotropic shrinkage of wood.

It was shown also that in beech (2), fine rays possessed a radial shrinkage potential similar to that of broad rays. By varying the relative proportion of ray tissue contained in transverse sections of beech, a relationship was found to exist between the radial shrinkage of transverse sections and the proportion of the sections occupied by ray tissue. Extrapolation of this relationship to zero ray volume resulted in obtaining a value for the radial shrinkage of "rayless" wood which was approximately equal to the tangential shrinkage of springwood and summerwood shrinking together. Similar results were found with red oak.

Tests were continued at the Ottawa Laboratory of the Forest Products Laboratories of Canada to determine the effect of shrinkage of certain tissues on the gross shrinkage of the wood of red oak and beech. Tests were made on sections, 80 microns in thickness, cut by means of a microtome. Measurements were made with a travelling microscope as previously described (1) (2). Drying of the specimens was accomplished over phosphorus pentoxide in closed desiccators fitted with plate glass tops through which dry dimensions were measured

This report describes an equation which was derived to determine the value of the radial shrinkage of "rayless" wood of both red oak and beech for comparison with that obtained from extrapolation of the relationship mentioned above. Included are results of tests to determine the longitudinal (parallel to the grain of the wood) and tangential shrinkage of broad rays. Experimental measurement data are presented which show the radial and tangential shrinkage of springwood and summerwood of red oak and beech.

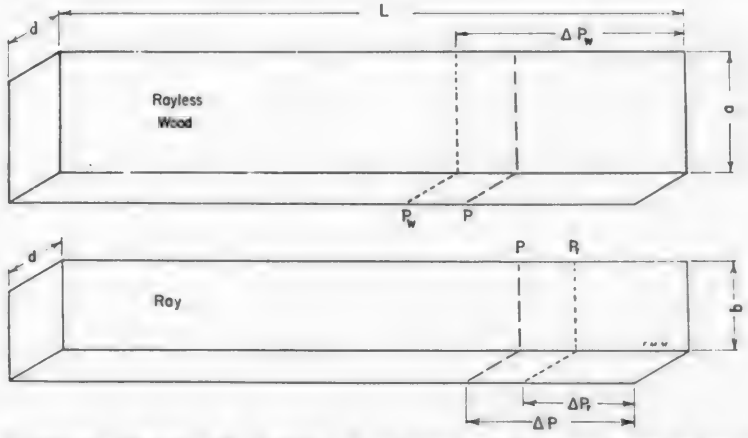

Fig. 1.—Diagram illustrating the shrinkage of ray tissue and of "rayless" wood for use in a theoretical consideration of the interaction of these two types of tissue.

[1] A contribution from the Ottawa Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources.

[2] This article essentially is part of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Wood Technology, State University of New York College of Forestry at Syracuse.

[3] Numbers in parentheses refer to literature cited.

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Observations and Results

1. Theoretical Radial Shrinkage of "Rayless" Wood: No satisfactory laboratory method was devised for measuring the radial shrinkage of "rayless" wood of red oak or beech because of the difficulty of isolating such material. However, by means of equation 9 (given later) it is possible to arrive at a theoretical value in terms of variables whose actual values can be measured.[4]

Consideration should be given to the diagram in Fig. 1. When longitudinal woody tissue is isolated from ray tissue, the rayless wood may be said to shrink (S_w) to P_w while the ray tissue shrinkage (S_r) is to P_r. When the two types of tissue shrink (as in an ordinary undissected piece of wood) they exert stresses on each other and the resultant shrinkage (S) is to point P. In this case, therefore, there is a tension set up in the rayless wood and a compression in the ray.

From consideration of the stresses occuring in the wood when drying, it may be shown (equation 8)[5] that:

$$S = \frac{100E_oS_w(100 - S_r) - V_o\,[E_oS_w(100 - S_r) - S_r\,(100 - S_w)]}{100E_o(100 - S_r) - V_o\,E_o\,(100 - S_r) - (100 - S_w)]}$$ —Equation 8

where:

- S = % shrinkage of rays and rayless wood shrinking together from green to dry condition.
- E_o = ratio of the modulus of elasticity of the rayless wood to the modulus of elasticity of the rays.
- S_w = % shrinkage of isolated rayless wood from green to dry condition.
- S_r = % shrinkage of isolated rays from green to dry condition.
- V_o = % ray volume.

Equation 8 may be used to predict the radial shrinkage of the gross wood if the radial shrinkage of the isolated rays and of the rayless wood, the ray volume, and the parameter E_o are known. However the shrinkage of the isolated rayless wood (S_w) and the parameter E_o are unknown, whereas the radial shrinkage of the gross wood (S) and of the isolated rays (S_r) may be experimentally observed.

Both S_w and E_o may be obtained by fitting equation 8 to experimental data. This is accomplished by selecting two points on the experimental curves relating the radial shrinkage of transverse section to the volume of the sections occupied by ray tissue, and substituting the corresponding values of S and V_o into the equation. As any points so selected lie on the same curve, a pair of simultaneous equations in two unknowns (E_o and S_w), each satisfying equation 9 may be obtained.

Rearranging equation 7 of the Appendix to a form convenient for simultaneous solution:

Equation 9—

$$V_o\,(S - S_r)(100 - S_w) = E_o\,(100 - V_o)(S_w - S)(100 - S_r)$$

The resulting pair of equations (10 and 11) from equation 9 above are:

Equation 10—

$$V_{o1}\,(S_1 - S_r)(100 - S_w) = E_o\,(100 - V_{o1})(S_w - S_1)(100 - S_r)$$

Equation 11—

$$V_{o2}\,(S_2 - S_r)(100 - S_w) = E_o\,(100 - V_{o2})(S_w - S_2)(100 - S_r)$$

From experimental data obtained on red oak the following pair of points were selected for solution of equations 10 and 11:

$V_{o1} = 15\%$ $S_1 = 4.75\%$
$V_{o2} = 25\%$ $S_2 = 4.1\%$
$S_r = 2.59\%$

Eliminating E_o by dividing equation 10 by equation 11, solving for S_w and then substituting the experimental data cited above, it is determined that S_w (i.e., the radial shrinkage of "rayless" wood) for red oak is approximately 6.8%.

Similarly for beech, data were selected from 2 points on the experimental curve for substitution in equations 10 and 11 as follows:

$V_{o1} = 16\%$ $S_1 = 6.73\%$
$V_{o2} = 25\%$ $S_2 = 5.4\%$
$S_r = 2.32\%$

Calculations show the value of S_w for beech to be 12.7%.

It has therefore been determined that the radial shrinkage of red oak free of all rays is 6.2% (from extrapolation of experimental curve) compared to 6.8% (from equation). In the same manner, the radial shrinkage of beech, free of all rays is 11.7% (from extrapolation of experimental curve) compared to 12.7% (from equation).

It is possible with information available to solve equation 9 so as to obtain a value for E_o (ratio of the modulus of elasticity of wood without rays to the modulus of elasticity of ray tissue) in the radial direction.

Using the following data for red oak:

$V_{o3} = 30\%$ ray volume
$S_3 = 3.88\%$ (shrinkage corresponding to ray volume at 30% from experimental data)
$S_w = 6.8\%$ (from equation)
$S_r = 2.59\%$
Therefore, E_o (red oak) = 0.181

Similarly, substitution of the following data for beech was made into equation 9:

$V_{o3} = 30\%$ ray volume
$S_3 = 4.88\%$ (shrinkage corresponding to ray volume at 30% from experimental data)
$S_w = 12.7\%$ (from equation)
$S_r = 2.32\%$
Therefore, E_o (beech) = 0.12

It is therefore calculated, by means of substituting experimental data into equation 9, that the ratio (E_o) of the modulus of elasticity of wood without rays to the modulus of elasticity of ray tissue in the radial direction of transverse sections under test is 0.181 for red oak and 0.124 for beech.

Figs. 2 and 3 for red oak and beech are included to show the relationship between fractional ray volume and per cent radial shrinkage obtained from equation 9 where E_o for red oak is 0.181 and where E_o for beech is 0.124. Radial shrinkage values for transverse sections of red oak, with various proportions of ray tissue are shown in Fig. 2 while similar shrinkage values for transverse sections of beech, the plotted in Fig. 3. The agreement between the shape of the curves obtained from the equation and the plotted experimental shrinkage data is very close.

2. Longitudinal and Tangential Shrinkage of Broad Rays: Measurements of the radial and of the longitudinal shrinkage (in the direction of the grain of the wood) of broad rays of red oak and beech were made on radial sections composed entirely of broad ray tissue which were 80 microns in thickness. The results of these measurements for both species are presented in Table 1.

Statistical comparison of the data indicates that there is a highly significant difference between the longitudinal and radial shrinkage of broad rays of the red oak studied. With regard to broad rays of beech, the re

[4] This equation is based on a derivation offered by R. E. Pentoney, State University of New York College of Forestry at Syracuse.

[5] Derivation of equation 8 is shown in the Appendix.

Table 1.—COMPARISON OF RADIAL AND LONGITUDINAL SHRINKAGE OF BROAD RAY TISSUE MEASURED ON RADIAL SECTIONS *

Shrinkage Measured	Number of Specimens	Mean Shrinkage per cent	Standard Deviation
Red Oak			
Longitudinal	8	3.41	0.34
Radial	9	2.46	0.28
Beech			
Longitudinal	7	5.69	0.43
Radial	8	2.15	0.12

* microns in thickness.

Table 2.—COMPARISON OF RADIAL SHRINKAGE OF BROAD RAYS ISOLATED FROM TRANSVERSE AND RADIAL SECTIONS *

Broad Rays from:	Number of Specimens	Mean Radial Shrinkage per cent	Standard Deviation
Red Oak			
Transverse Sections	11	2.59	0.18
Radial Sections	9	2.36	0.28
Beech			
Transverse Sections	10	2.32	0.06
Radial Sections	8	2.15	0.12

*80 microns in thickness.

sults in Table 1 show a larger difference between the longitudinal and radial shrinkage of broad rays than that found for red oak. The longitudinal shrinkage of broad rays of beech is larger than that of broad rays of red oak.

It is of interest to compare the radial shrinkage of broad rays isolated from transverse sections and that of broad rays obtained from radial sections. This comparison for red oak and beech is made in Table 2. The data presented in Table 2 for the radial shrinkage of broad rays isolated from transverse sections is, of course, the same as presented previously for red oak and beech.

Statistical comparison of the significance of the difference between the mean radial shrinkage of broad ray tissue of red oak isolated and measured both ways indicated that the difference between the means is barely significant at the 5% level of probability whereas analysis of the data for beech does indicate significant difference between results obtained with the two different methods of measurement. In red oak the radial shrinkage measurements of broad rays isolated from transverse sections gave nearly 10% higher mean values than those made on rays isolated from radial sections, whereas the same method for beech gives a figure just under 8% higher than was found for radial sections.

The tangential shrinkage of isolated broad rays was difficult to determine because of their small tangential dimensions. Results of tentative measurements made on broad rays of red oak isolated from tangential sections indicate that their tangential shrinkage is approximately 9.0%. No measurements of tangential shrinkage of isolated broad rays of beech were attempted.

3. **Radial and Tangential Shrinkage of Isolated and Non-Isolated Springwood and Summerwood:** A. **Red Oak**—The results of shrinkage measurements made on springwood and summerwood of red oak on transverse sections 80 microns thick are presented in Table 3. To aid in the interpretation of the results in Table 3 the following description of the material and measurements, along with designations appearing in the table, are given:

(a) Isolated springwood—Radial and tangential shrinkage measurements were made on springwood (vessel area) which was isolated by means of a scalpel from transverse sections. No broad rays were included. Narrow rays were present.

(b) Isolated summerwood—Measurements of radial and tangential shrinkage were made on summerwood isolated from transverse sections. No broad rays were included. Narrow rays were present.

(c) Tangential shrinkage of non-isolated springwood and summerwood—These measurements were made between 2 adjacent broad rays on transverse sections using edges of vessels close to each broad ray as reference points. In this group of measurements, the springwood and summerwood appeared to shrink the same amount tangentially since the sections were sufficiently wide to avoid edge effects.

(d) Radial shrinkage of springwood and of summerwood when not isolated—Values were obtained from transverse sections from which broad rays had been separated. The springwood radial shrinkage was measured from edges of vessels within the springwood areas. Summerwood shrinkage was measured between edges of vessels lying next to and on each side of the summerwood bands.

For comparison, the radial shrinkage of springwood and summerwood shrinking together is entered as item (e) in Table 3.

B. Beech: Results of determination of the radial and tangential shrinkage of springwood and summer-

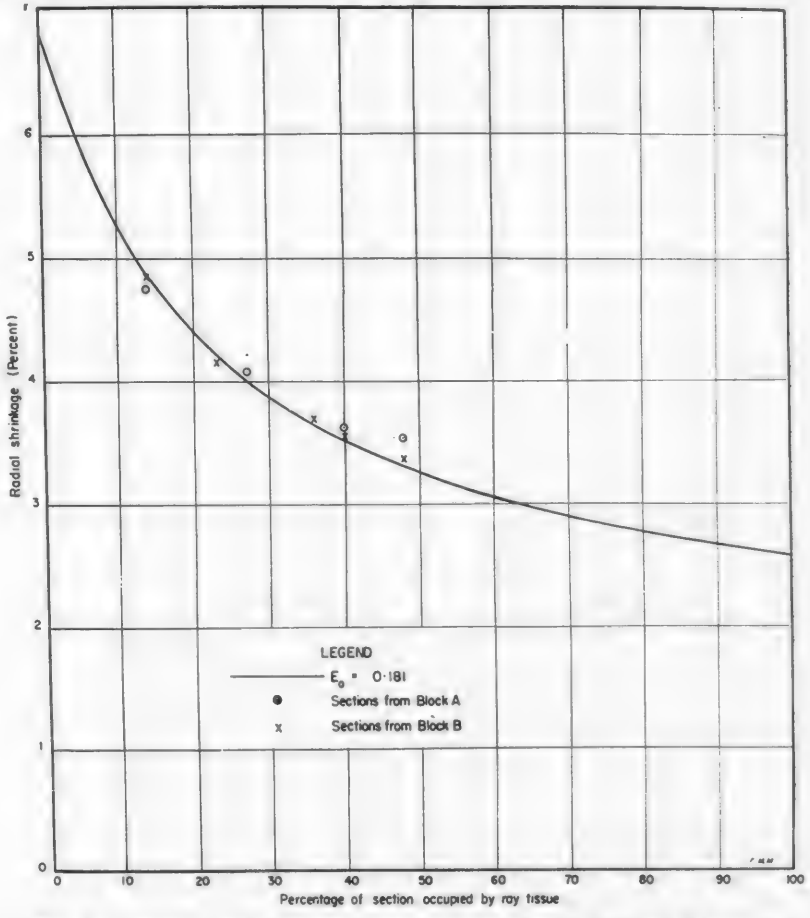

Fig. 2.—Theoretical and experimental relation between radial shrinkage of transverse sections of red oak and volume of sections occupied by ray tissue.

Table 3.—RED OAK—RADIAL AND TANGENTIAL SHRINKAGE OF SPRINGWOOD AND SUMMERWOOD

Material* and direction of measurement	Number of Specimens	Mean Shrinkage per cent	Standard Deviation
(a) Isolated springwood			
Tangential	19	5.10	0.46
Radial	20	2.58	0.55
(b) Isolated summerwood			
Tangential	19	8.37	0.33
Radial	17	8.14	0.64
(c) Tangential shrinkage of springwood and summerwood combined	15	7.60	0.29
(d) Radial shrinkage of non-isolated			
Springwood	18	2.09	0.45
Summerwood (without broad rays)	16	6.34	0.64
(e) Radial shrinkage of wood with no broad rays	60	4.83	0.22

*Transverse sections, 80 microns in thickness.

Table 4.—BEECH—RADIAL AND TANGENTIAL SHRINKAGE OF SPRINGWOOD AND SUMMERWOOD

Material* and direction of measurement	Number of Specimens	Mean Shrinkage per cent	Standard Deviation
(a) Isolated springwood			
Tangential:			
(i) early	15	12.00	0.52
(ii) halfway through annual ring	9	11.32	0.36
Radial	10	5.71	0.27
(b) Isolated summerwood			
Tangential	22	10.71	0.36
Radial	--	9.8†	---
(c) Tangential shrinkage of springwood and summerwood combined	18	11.62	0.27
(d) Radial shrinkage of wood with no broad rays	14	6.73	0.13

*Transverse sections, 80 microns in thickness.
†Computed value: See explanation under Beech (b).

wood of beech measured on transverse sections are given in Table 4. As with the previous table for red oak, the following information describes the material and measurements of samples of beech, along with designations appearing in Table 4.

(a) Isolated springwood—Measurements of radial and tangential shrinkage were made on springwood (about 75% of the annual ring in the radial direction) which was isolated from transverse sections by means of a scalpel. No broad rays were included but fine rays were, of course, present. Tangential shrinkage measurements were made on the first formed springwood and on springwood at about the middle of the annual ring.

(b) Isolated summerwood—Tangential shrinkage was measured on summerwood (the last formed 25% of the annual ring). No radial shrinkage measurements were made on these specimens because of the small radial dimensions. Instead, the radial shrinkage of summerwood was computed from measurements of the radial shrinkage of springwood and that of springwood and summerwood shrinking together. No broad rays were included, but fine rays were present.

(c) Tangential shrinkage of non-isolated springwood and summerwood —Measurements in this test were made between two broad rays on transverse sections. Edges of vessels close to each broad ray were taken as reference points. The tangential shrinkage of springwood and summerwood shrinking together in relatively wide sections appeared to be the same.

(d) Radial shrinkage of non-isolated springwood and summerwood —This information was obtained from measurement of the radial shrinkage of transverse sections without broad rays.

Conclusion

A fourth and final article on the shrinkage of red oak and beech is in preparation and will be published shortly. This article will summarize and discuss the results of tests conducted to determine the shrinkage of rays and its probable effect on the differential transverse shrinkage of wood.

Literature Cited

1. McIntosh, D. C. 1954. Some aspects of the influence of rays on the shrinkage of wood. J. For. Prod. Res. Soc. IV (1): 39–42.
2. McIntosh, D. C. 1955. The effect of rays on the radial shrinkage of beech. For. Prod. J. V (1):67–71.

Appendix

Derivation of Equation 8

Let the following symbols represent the corresponding radial conditions:

F_w = Tension force in rayless wood
e_w = Strain in rayless wood
s_w = Stress in rayless wood
E_w = Modulus of elasticity for rayless wood
F_r = Compressive force in rays
e_r = Strain in rays
s_r = Stress in rays
E_r = Modulus of elasticity for rays
S_w = % shrinkage of isolated rayless wood from green to dry condition
S_r = % shrinkage of isolated rays from green to dry condition
S = % shrinkage of rays and rayless wood shrinking together from green to dry condition
V_w = Volume of rayless wood
V_r = Volume of rays.

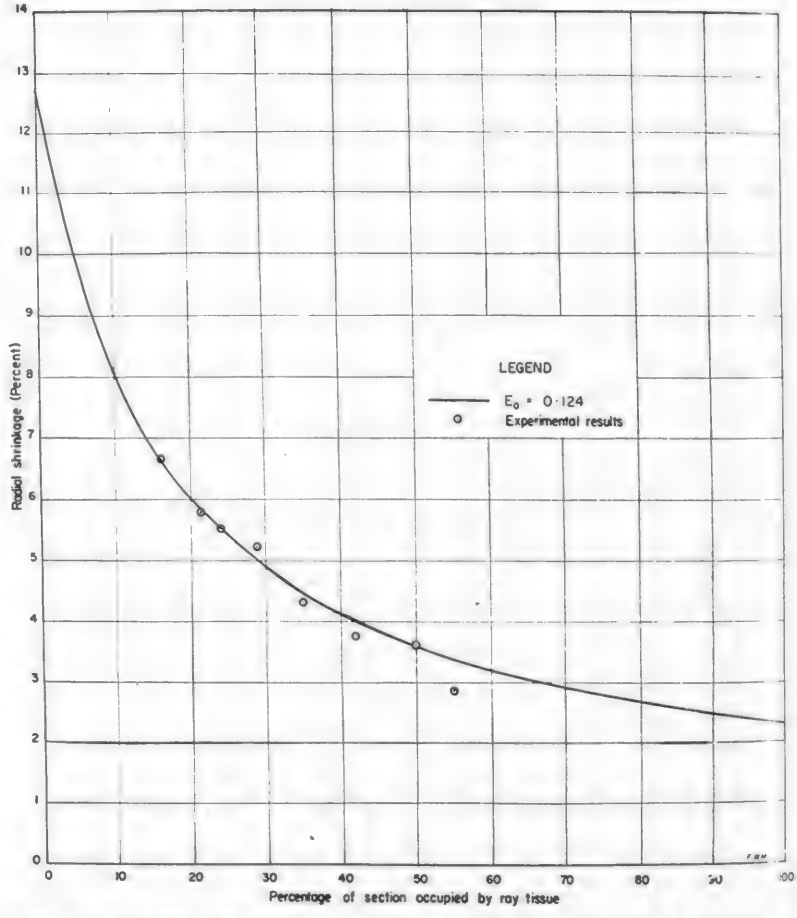

Fig. 3.—Theoretical and experimental relation between radial shrinkage of transverse sections of beech and volume of sections occupied by ray tissue.

At equilibrium, $\Sigma F = 0$

$F_w + F_r = 0$

$F_w = -F_r$

By definition, $E = \frac{s}{e} = \frac{e}{F/A}$

where A = area over which the force is applied

$\therefore \quad F_w = E_w e_w A_w = E_w e_w ad$

$F_r = E_r e_r A_r = E_r e_r bd$

$E_w e_w ad = -E_r e_r bd$

$$\frac{E_w}{E_r} = -\left(\frac{e_r}{e_w}\right)\left(\frac{bd}{ad}\right) = -\left(\frac{e_r}{e_w}\right)\left(\frac{bdL}{adL}\right)$$

But $bdL = V_r$ = the volume of the rays

$adL = V_w$ = the volume of the rayless wood.

$$\therefore \quad \frac{E_w}{E_r} = -\left(\frac{e_r}{e_w}\right)\left(\frac{V_r}{V_w}\right) \text{---------} (1)$$

Let $E_o = \frac{E_w}{E_r}$ ---------- (2)

and V_o = % ray volume $= \frac{V_r}{V_r + V_w} \times 100$

$$\therefore \quad \frac{V_r}{V_w} = \frac{V_o}{100 - V_o} \text{----------} (3)$$

Substituting equations 2 and 3 into equation 1,

$$E_o = -\frac{e_r}{e_w}\left(\frac{V_o}{100 - V_o}\right) \text{-------} (4)$$

By definition, strain e is the deformation divided by the original length of the number.

$$\therefore \quad e = \frac{\text{new length} - \text{old length}}{\text{old length}}$$

$$\therefore \quad e_r = \frac{(L - \Delta P) - (L - \Delta P_r)}{L - \Delta P_r} = \frac{\Delta P_r - \Delta P}{L - \Delta P_r}$$

Dividing numerator and denominator of the right side by L:

$$e_r = \frac{\Delta P_r/L - \Delta P/L}{1 - \Delta P_r/L}$$

Multiplying the numerator and denominator by 100:

$$e_r = \frac{\Delta P_r/L \cdot 100 - \Delta P/L \cdot 100}{100 - \Delta P_r/L \cdot 100}$$

If L is taken as the green dimension,

$S_r = \Delta P_r/L \cdot 100$

$S = \Delta P/L \cdot 100$

$$\text{and } e_r = \frac{S_r - S}{100 - S_r} \text{----------} (5)$$

Similarly

$$e_w = \frac{S_w - S}{100 - S_w} \text{----------} (6)$$

Substituting equations 5 and 6 into equation 4,

$$E_o = \frac{(S - S_r)(100 - S_w)}{(S_w - S)(100 - S_r)} \cdot \frac{V_o}{100 - V_o} \text{----------} (7)$$

Solving for S,

$$S = \frac{E_o S_w (100 - S_r)(100 - V_o) + V_o S_r (100 - S_w)}{E_o (100 - S_r)(100 - V_o) + V_o (100 - S_w)}$$

$$S = \frac{100\, E_o S_w (100 - S_r) - V_o [E_o S_w (100 - S_r) - S_r (100 - S_w)]}{100\, E_o (100 - S_r) - V_o [E_o (100 - S_r) - (100 - S_w)]} \text{----------} (8)$$

Accuracy of Electric Moisture Meter Readings on Jack Pine Posts[1]

JAMES S. MATHEWSON

Engineer, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Transverse moisture-content average and distribution in air-seasoned jack pine fence posts was estimated by resistance type of moisture meter used with special electrode. Results were compared with average moisture content values determined by the oven-drying method.

A RESISTANCE TYPE OF MOISTURE METER has been found in a study at the U. S. Forest Products Laboratory to be a satisfactory means, in comparison with oven-drying methods, of estimating the transverse moisture-content average and distribution in air-seasoned jack pine fence posts when used with a special electrode and when the average moisture content is less than 30 per cent, subject to a correction factor of 4 or 5 per cent applied to moisture-meter readings taken at any depths in the posts. No attempt has been made to indicate correction factors for fence posts of other diameters than those involved in the study. For the present purpose, a variation of several per cent is not important.

[1] A contributed paper.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Author: James S. Mathewson is a graduate of Mechanical Engineering College, U. of Cincinnati. He has conducted research in air seasoning of lumber, crossties, and poles; kiln drying of lumber; and storage of lumber.

Procedure

Twenty peeled jack pine fence posts 7.5 feet long were used. The diameters at midlength ranged from 5.6 to 8.1 inches and averaged 6.7 inches. On arrival at the Laboratory on Aug. 25, 1950, the posts were end-coated and the circumferences were measured at the top, butt, and 2 feet from the butt. In each of 10 of the posts located in alternate tiers and in each layer, escutcheon pins to be used as electrodes were driven to depths of 0.375 inch; also to 0.9 inch in one group of 7 posts and to 1 inch in the others. No. 18 insulated copper wires were soldered to the pins and connected through a jack box to a moisture meter as shown in Fig. 1. The posts were open-piled in a building previously

Fig. 1.—Jack pine fence posts piled for air seasoning in an open shed. At the right are shown wires that lead from escutcheon pins driven into 10 of the posts and that are connected through a jack box to a moisture meter.

Fig. 2.—Pile of fence posts and special electrode and moisture meter. (The meter is the same as shown in Fig. 1.)

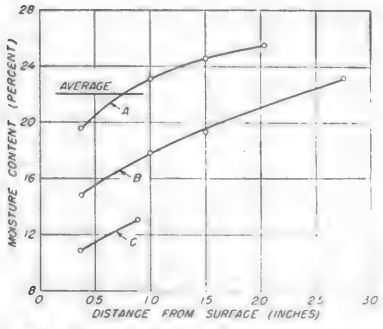

Fig. 3.—Transverse moisture-distribution curves for seven air-seasoned jack pine fence posts: curve A, based on oven-drying determinations; curve B, based on moisture-meter readings taken with special electrode shown in Fig. 2; and Curve C, based on moisture-meter readings taken with escutcheon pins. The horizontal line designated "Average" is based on the average of moisture-content values, determined by the oven-drying method, for whole disks cut adjacent to those used for the determination of moisture-content distribution.

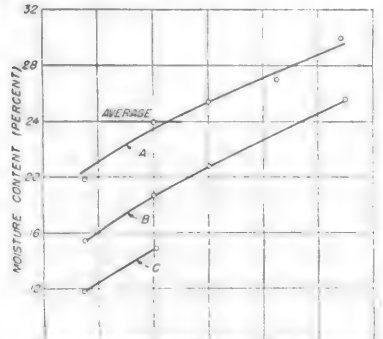

Fig. 4.—Transverse moisture-distribution curves for 13 air-seasoned jack pine fence posts: curve A, based on oven-drying determinations; curve B, based on moisture-meter readings taken with a special electrode; and curve C, based on moisture-meter readings taken with escutcheon pins. The horizontal line designated "Average" is based on the average of moisture-content values, determined by the oven-drying method, for whole disks cut adjacent to those used for the determination of moisture-content distribution.

used as a furnace kiln. The door was left open during the air-seasoning period of 2 months. During this time readings were taken with a resistance type of moisture meter at approximately weekly intervals.

At the end of the seasoning period the special electrode shown in Fig. 2 was used to take readings when the pins were driven successively to depths of 0.375, 1.0, 1.5, and 2.75 inches at a section 2 feet from the butt. From each post two 1-inch disks were cut where the readings were taken. One disk was cut into annuli and a core for oven-drying determination of transverse moisture-distribution values for comparison with the moisture-meter readings. The other disk was used to determine the average moisture content by the oven-drying method. The depth of sapwood of this disk was measured along two lines approximately at right angles to each other because the disk was more nearly oval than circular.

Table 1.—COMPARISON OF AVERAGE-MOISTURE-CONTENT VALUES (DETERMINED BY THE OVEN-DRYING METHOD) WITH MOISTURE-METER READINGS FOR EACH OF TWO GROUPS OF JACK PINE FENCE POSTS (OCT. 23–24, 1950)

Post No. (1)	Average moisture content (2) Per cent	Moisture-meter readings at 1-inch depth (3) Per cent	Column 2 minus column 3 (4) Per cent
1	23.2	18.5	4.7
2	21.5	18.0	3.5
3	22.0	17.5	4.5
14	22.1	17.5	4.6
15	22.1	18.0	4.1
19	22.2	17.5	4.7
20	21.4	17.5	3.9
Av.	22.1	17.8	4.3
4	23.7	18.5	5.2
5	25.8	20.5	5.3
6	24.7	18.5	6.2
7	24.7	19.0	5.7
8	23.3	17.5	5.8
9	24.5	18.0	6.5
10	23.4	19.0	4.4
11	23.7	19.5	4.2
12	23.5	19.0	4.5
13	21.9	17.5	4.4
16	24.3	19.0	5.3
17	22.9	17.0	5.9
18	25.2	19.0	6.2
Av.	24.0	18.6	5.4

Results

The depth of sapwood at about 2 feet from the butt ranged from 1.1 to 1.8 inches and averaged 1.3 inches.

Table 1 presents a comparison of average moisture-content values (determined by the oven-drying method) with moisture-meter readings taken at a depth of 1 inch in each air-seasoned fence post.

In Fig. 3, curve A shows the average transverse moisture-content distribution for a group of seven air-seasoned posts; curve B, corresponding moisture-meter readings taken with a special electrode; and curve C, moisture-meter readings taken with escutcheon pins driven to a depth of 0.375 inch and of 0.15 of the average diameter of the posts 2 feet from the butt.

Fig. 4 is similar to Fig. 3 and relates to a second group of 13 air-seasoned posts.

The 7 posts were not large enough to permit cutting each disk into 4 annuli and a core as was done with the 13 other posts; the disk from each of the 7 posts was cut into only 3 annuli and a core.

Discussion of Results

Table 1 shows a rather surprisingly narrow range of moisture-content values, 21.4 to 23.2 per cent, averaging 22.1 per cent, for the first group of 7 posts, and 21.9 to 25.8 per cent, averaging 24.0 per cent, for the second group of 13 posts. The difference in average diameters of the two groups was 1 inch, and this may be the principal reason for the higher average moisture content of the second group, which had the larger average diameter.

The differences between average moisture-content values and moisture-meter readings taken at a depth of 1 inch ranged from 3.5 to 4.7 per cent, averaging 4.3 per cent, for the group of 7 posts; and the corresponding range and average were, respectively, 4.2 to 6.5 per cent and 5.4 per cent for the group of 13 posts.

Table 1 and Figs. 3 and 4 indicate that, below the fiber saturation point, a fair estimate of the moisture-content average and distribution in jack pine fence posts can be obtained by increasing the moisture readings at any depth by 4 or 5 per cent. Such a correction may be required because of the unknown electrical-resistance, moisture-content relationship for jack pine, and also because of checking that would increase the contact resistance of the electrode.

Curve C in Fig. 3 and in Fig. 4 is about 4 per cent lower than curve B in each figure.

The data for curve B in each figure were obtained with a special electrode, and the data for curve C in each figure were obtained with brass escutcheon pins. Possibly the checking around the escutcheon pins, which had been driven 2 months earlier, had a greater effect on contact resistance than that around the special electrode driven only a moment before the readings were taken. The increased contact resistance of the escutcheon pins would result in lower moisture-meter readings than those taken with the special electrode.

According to the average moisture content determined by the oven-drying method and represented by the horizontal lines marked "Average" in Figs. 3 and 4, these lines intersect the transverse moisture-distribution curve A at about 0.77 and 1.12 inches, respectively, from the surface. The respective average diameters of the two groups of posts were 5.84 and 6.85 inches. Hence $\frac{0.77}{5.84} = 0.13$, and $\frac{1.12}{6.85} = 0.16$. Theoretically, the ratio of the depth at which the average moisture content of a cylinder occurs is 0.15 of the diameter. Thus the depth at which the average moisture content of the air-seasoned jack pine fence posts occurred approximated that indicated by theoretical considerations.

Relationship of Oil Carriers to Utility of Pentachlorophenol as a Wood Preservative[1]

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Penta wood preserving formulations are classified into four basic types. Information is given on the constituents of the formulations for each type, how each type may be applied to wood, the characteristics of each type of formula, and the basic end uses for each type.

WOOD PRESERVATIVES are generally classified as oil preservatives, oil-borne preservatives, or water-borne preservatives. Pentachlorophenol (hereinafter called Penta for brevity, since it is known by that nickname in the wood preservation field) is a high-melting, crystalline, oil soluble solid. It is commonly used in the form of petroleum oil solutions, and therefore falls in the oil-borne classification. Many substances are better solvents for Penta than petroleum oils, for examples, diacetone alcohol, pine oil, ketones, alcohols, etc., but other properties and costs make them less suitable as basic solvents or carriers for Penta in most commercial wood preservation applications.

It is well known that one can obtain petroleum oils to meet any one of a hundred specifications in terms of gravity, distillation range, color, odor, flash point, or other characteristics. They also vary in availability and price. And, so far as Penta is concerned, they might be good or poor solvents.

With these brief facts, let us consider the characteristics that might influence the choice of one or more oils as basic carriers for Penta in the preparation of wood preservative formulations. Since it is common practice to use 5% solutions of Penta for wood preservation, certainly the formula should hold that percentage of Penta in solution not only at use temperatures, but at the lowest storage and shipping temperatures in the area where the product will be available. Hence one consideration in selecting an oil will be—how much Penta will it *hold* in solution at a given temperature?

There have been conflicting answers given as to the Penta solvency for the same oil tested at different laboratories, primarily because of the variation in methods used in determining the solvency. To illustrate, two laboratories tested the solubility of Penta in six different petroleum oils by two different current methods. The results are given in Table 1.

Table 1.—SOLUBILITY OF VARYING QUANTITIES OF PENTACHLOROPHENOL IN SIX DIFFERENT PETROLEUM OILS

Oil	Solution point by Monsanto Method[2]		Solubility by AWPA Method A5-54
	% Penta	T in °F.	
A	15	58	20% at −15° F.
	20	85	
	25	109	
B	5	48	Over 5% at −15° F.
C	10	50	
	15	79	Over 10% at −15° F.
	20	105	
D	14	86	20% at −15° F.
E	5	14	
	10	34	5% at −15° F.
	15	86	
F	10	99	Over 10% at −15° F.

[2]Method is described in Monsanto Technical Bulletin No. 0-25 entitled, Pentachlorophenol-Technical [Santophen* 20 (*Reg. U. S. Pat. Off)], dated June 1955.

The discrepancies shown in Table 1 come about because solutions prepared by the AWPA method can become supersaturated upon cooling and ultimately some Penta may crystallize out of solution. The solution point method eliminates the chances of producing a supersaturated solution. Therefore, it has much to commend it as a test method, for its use would help refineries and users alike to better evaluate the utility of an oil as a suitable carrier for Penta.

As previously mentioned, Penta solvency is not the only determining factor by which to judge a petroleum oil. The end use for the treated item will also help determine the desired characteristics of the oil. This poses a problem for the wood treater who wishes to go after all types of business for, as will be pointed out, no one oil or no one formula can cover the entire end-use field.

In the broadest sense, there are four types of Penta formulations in use today. From the discussion that follows, it will be seen that there is not

[1] Presented at Session IV, Smog Control, Electric Drives, and Wood Preservation, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

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a clear-cut dividing line between each type (especially Type II and Type III), but the differentiation so far as characteristics and end use of the different types of formulations should be well understand. For ease in referring back to these types, they will be designated as Types I, II, III, and IV.

Starting with the cheapest formula, the Type I formula is defined as one containing 5% Penta and 95% of a residual or residuum oil. As the names of these oils indicate, they are the materials remaining after other items have been removed by catalytic and other refining processes. Their composition varies so widely that no useful specification can be given for them so far as wood preservation formulations are concerned, but because of their chemical characteristics, any of them tested to date have proved to be suitable carriers for Penta. A solution made from either a residual or residuum oil will be dark (practically black), viscous, will have some odor, and can be successfully applied to wood only by the pressure method. These oils solubilize Penta readily, and since they are very low in volatility, the Penta does not bloom (crystallize) on the surface of wood treated with such formulations. Information on the treatment of railroad ties with such a formulation was published by Hatfield[3] in 1944, and service records to date show the ties are in fine condition. Ties treated commercially with this type of formula indicate the material helps prevent checking and "brooming" (fanning out) of the ties.

Just as Type I Penta preservative solutions contain only two ingredients —Penta and a very heavy oil, so Type II formulae contain only two components. These are Penta and usually either a No. 2 or a No. 3 fuel oil, diesel oil, or some other oil that will easily dissolve and hold 5% Penta in solution at the working and storage temperatures existing in the treating area where they will be used.

It was mentioned earlier that the line of demarcation between the four types of formulae was not distinct. Probably there is no greater variation in composition in any of the four types than in this group designated as Type II. Also, there has existed some confusion of thought about what solutions of this type could do. For instance, the American Wood-Preservers' Association Preservatives Committee in 1949[4] proposed a specification for a petroleum oil to be used in preparing Penta formulations, and one of its chief characteristics was that "the total volume of the fractions distilling below 500° F. shall be not more than 50 per cent." When that Committee reported in 1950,[5] they stated "From the studies made thus far we have reached the conclusion that there should be at least two specifications as follows: 1. Heavy solvent (present specification); 2. Light solvent."

The report stated that, for the light petroleum solvent, "the total volume of the fractions distilling below 500° F. shall be not more than 60 per cent. The total volume of the fractions distilling below 625° F. shall be not less than 90%."

Thus it is seen that the light petroleum solvent had the low and high boiling fractions essentially fixed in an attempt to reduce the amount of oil that would remain in the wood. The hope was that these light oils would produce a cleaner, possibly paintable, treatment that would have less tendency to bleed than was the case when the heavy solvents were used.

Actually, it is believed that the solution to writing a specification for these Type II formulae will center around an understanding of what the end use will be for the treated wood. A heavy type of oil has been satisfactorily used to treat ties, poles, posts, and other wood items. The light type of oil will not give as good physical protection to these items, not because Penta is not a good preservative when used in light oils, but because the lighter oils often allow more checking and often allow migration of the retained solutions and crystallization of Penta (blooming) as the light oils volatilize.

To think that bleeding will be eliminated by use of light oils is to misunderstand the cause of bleeding. Whether solutions are forced into the wood by pressure or enter the wood by use of a steeping or other immersion method of treating, there will always be a greater quantity of oil in the outer cells of the treated item than in the inner cells (except in a truly full cell treatment). Changes in temperature will cause expansion of those oils, and the easiest and shortest distance for them to travel is to the wood surfaces. Because the heavy oils volatilize more slowly than the light ones, it appears that they bleed more, but that is not necessarily the case.

Furthermore, it has been speculated that some of the very constituents in the oil that increase Penta solvency are the constituents that adversely affect paintability. Hence a heavy oil type of formula that will not bleed and that will be satisfactorily paintable is practically out of the question so long as one is limited economically to fuel-type oils that are readily available and cheap.

To propose an angle for research that might prove fruitful, it is suggested that a research be made for a good, non-volatile solvent for Penta that will not interfere with the paintability of treated wood. Actually, linseed, fish, and tung oils act that way in Type IV formulations, but they have other adverse characteristics as well as price limitations which reduce their utility. In direct contrast to this approach, attempts have been made to produce satisfactory formulations by adding resins to them, the idea being that these resins would eliminate blooming and seal the wood surfaces.

The next type of Penta formula will be designated Type III. It usually contains as the carrier an oil less volatile than mineral spirits. Because the bulk of the oils used as carriers or diluents for wood preservatives are produced for fuel purposes, they are best known by names applying in the heating oil field. Such items as kerosenes, stove oils, No. 1 distillates, and some No. 2 distillates, fall into the group of oils generally used for this third type of Penta formulation. These oils distill between approximately 300° and 500° to 550° F., are relatively colorless, have only a slight odor, and, although they do not volatilize rapidly, the lower boiling fractions do leave the wood sufficiently rapidly to make the wood plaintable with certain types of paints within a relatively short time. The amount of preservative solution retained in the wood and especially the quantity in the outer one-half inch of the treated wood will have much to do with how soon after treatment the wood can be painted. If the outer cells are full of oil, bleeding is almost sure to occur, and when paint is applied before the oils dissipate, it may not dry properly or have good adhesion.

These oils will not hold 5% Penta in solution at normal working temperatures and their volatility is such that blooming is bound to occur unless a suitable anti-blooming agent is contained in the formula. Hence a formulation designed to fit into the Type III class will almost certainly require at least three ingredients: Penta, an anti-blooming agent which may and often does act as an auxiliary solvent, and the oil carrier. In some cases an additional auxiliary solvent will be required.

It might be pointed out that the writers have yet to find a failure despite the type of oil used where adequate Penta was present in the wood, but cases have been found where the proper formulation was not used,

[3] Hatfield, Ira. 1944. Information on pentachlorophenol as a wood preserving chemical. Proc. AWPA 40:47–65.

[4] AWPA. 1949. Report of Committee P-4, Non-Standard Preservatives. Proc. AWPA 45: 28–29.

[5] AWPA. 1950. Report of Committee P-4, Non-Standard Preservatives. Proc. AWPA 46: 33–34.

Penta was depleted from the wood or the treating method did not get sufficient Penta into the wood, and failures were reported. These should not be charged against the value of Penta, but should cause treaters and users alike to seek a type of Penta treatment that can and will produce good results.

The Penta formulation designated as Type IV will represent the cleanest, most quickly paintable and probably the most expensive type of Penta formulation. Most Type IV formulae are designed to impart both preservative and water-repellent characteristics to the wood. Regardless of who develops such a formula, the carrier oil will probably be mineral spirits as defined in Federal Specification TT-T-291, Grade I—Light Thinner (since it is the most easily and economically available petroleum having a flash point of 100° F. or over; 105° F. is common), and will possess sufficient volatility so that it does not appreciably retard the drying of paint applied to the wood a few days after treatment.

Since mineral spirits is a poor solvent for Penta (it will dissolve and hold only about 1% of Penta at room temperature) and volatilizes rapidly, an anti-blooming agent and/or an auxiliary solvent are required to make a stable 5% formulation of the Type IV class. Auxiliary solvents may be selected from any group of products that readily dissolve Penta, do not hamper paintability, and which will remain stable during the storage and use period of the formula. Such items may be pine or other vegetable oils, or synthetic materials. Anti-blooming agents are substances of low volatility, preferably having high solvency for Penta. They are sometimes used in combination with waxes to act as water-repellents.

Having categorized roughly four types of Penta formulations, it is apparent that the types of oil carriers help indicate the other constituents to be used in a formulation and that they also influence the end use for such formulations. That brings us to a necessary part of this representation which is—what about concentrates of Penta? Since carriers constituted the greater part of 5% ready-to-use solutions, and since petroleum oils such as fuel oils or mineral spirits were generally easily available locally at a price lower than the delivered price of that amount of oil shipped in a formulation, it was early recognized that shipping concentrates might have a marked advantage price-wise.

Generally two types of concentrates have been sold. The preservative-water repellent concentrate usually was a 3 to 1, 4 to 1, or 5 to 1 product, i.e., either 3, 4, or 5 gallons of the diluent or carrier could be used with one gallon of concentrate to produce a 5% ready-to-use product. The other concentrate was a 10:1 item—ten gallons of diluent or carrier could be added to one gallon of concentrate to make a 5% ready-to-use product.

There are both good and bad features in these two types of concentrates. Discussing first concentrates of either type, the savings in shipping costs have been mentioned. Among other advantages would be that a laboratory with trained personnel could develop formulae that could be "cut" with a locally available oil, thus saving the ultimate user the problem of procuring the several required constituents. Futhermore, the cost of these individual items in small quantities would be high even if they were easily available, so the cost per gallon of a home-made formula might be higher than the cost of a concentrate. Some formulae would require special equipment for their preparation such as kettles, temperature control devices (thermometers, etc.), and stirrers, as well as a suitable source of heat. Hence, concentrates have had a very great appeal and literally millions of gallons of Penta concentrates have been sold.

But the use of concentrates has not been without disadvantages. Probably the worst offense was the selling of a 10:1 concentrate and indicating it would serve any end use regardless of the requirements imposed by that end use. Many labels have said in essence —cut this with mineral spirits and you will have a paintable formulation, cut it with No. 2 fuel oil and it will be good for treating posts, cut it with a heavier oil and it will serve still other purposes. Let's go back to either Type III or Type IV formulations. Both required an anti-bloom agent. Such a product is almost never present in a 10:1 concentrate. Therefore, 10:1 concentrates after dilution with mineral spirits or a No. 1 fuel oil usually will not produce a non-blooming ready-to-use solution, and it has been reported that some of these diluted concentrates will not hold 5% Penta in solution at low temperatures.

Still another disadvantage of these 10:1 formulae was the implied idea that they could be diluted with any oil, regardless of the gravity (weight per gallon) of the oil to produce a 5% Penta content in the treating solution. Because the required percentage by weight of Penta in a concentrate depends upon the gravity of the liquids that are used in making the concentrate and on the gravity of the diluent to be employed, the purchaser became confused by labels reporting a 38% Penta, 40% Penta, 42% Penta content, etc., thinking that a 42% Penta concentrate could be cut back more than a 38% one to make a 5% solution. Also, the feeling arose that one got a 5% Penta solution no matter what was used as a diluent if the rate of dilution was 10 gallons of diluent to one gallon of concentrate. In an attempt to overcome this consumer problem and to help get a fair basis for commercial sale of 10:1 concentrates, industry worked with the Commodity Standards Division of the U. S. Department of Commerce to develop a suitable commercial standard for 10:1 concentrates. Commercial Standard CS 194–53 entitled, "Pentachlorophenol Concentrate for Wood Preservation and Soil Poisoning" became effective August 24, 1953.

It was not the intent of these remarks about Penta concentrates to discourage their use where they could prove advantageous, but rather to point out problems that must be considered if they are to be used effectively and without disappointment as to the end results. Penta's universality of uses makes it extremely interesting as a good preservative. However, proper attention to formulation is necessary if consistently good results are to be obtained, and no one formula will be suitable for all end uses.

Penta can be successfully used in every field of wood preservation except for marine piling in open water, but its utility is influenced by the oils used as carriers as well as its distribution and retention in wood. Very different formulations have been successfully used for over 15 years on such diverse items as poles, sash and millwork, posts, wood flooring, and various other wood items. Thus it is evident that if proper formulations are used, Penta can serve a wide segment of the wood preservation industry.

Discussion

G. G. Garlick (Protection Products Mfg. Co.): When you find an oil having the solvency you need, you can't depend on each shipment to give you that solvency. You must test each load received to be sure it has the right solvency. The oil companies do not guarantee solvency. On your type IV (water repellent preservative) solution, the method of application varies the penetration so that deeper penetrations can be obtained where it is needed, depending on exposure.

Mr. Hatfield: Yes, that is a good point.

E. A. Behr (Chapman Chemical Co.): If two woods were treated with penta, one with penta in an oil carrier and one without an oil carrier (assuming this were possible), which piece of wood would last longer?

Mr. Hatfield: The wood treated with penta in oil would last longer. The less volatile oils, like Type I, would tend to hold the penta within the wood better than the more volatile solvents, like Type IV. In fact, we know that wood treated with an oil only can impart some deterioration resistance to wood.

W. M. Conners (Forest Products Laboratories of Canada): Should solvents vary according to the climate in which it will be used?

Mr. Hatfield: You get greater checking in dry regions and these checks, of course, expose untreated wood. The heavier oils will tend to reduce this surface checking.

Mr. Conners: Therefore wouldn't Type I oils be better in dry climates?

Mr. Hatfield: Yes. I would recommend the heaviest oil possible which will still permit you to meet the requirements of the end product—paintability, freedom from bleeding, etc.

W. R. Bond (American Wood Preservers Institute): I would like to substantiate Mr. Hatfield's comment and would point out further that the type of solvent supplied would depend upon the type of solvent being used by the pressure treating plant involved. At the present time, the general practice of most treating plants is to use the heavier oils for their penta solutions. I might say, however, that actual field experience indicates similar difficulties in painting over penta treatments as has been experienced with creosote, and the user should not be lead to expect that he can obtain a satisfactory result by simple methods.

Processing Test Data by the IBM System[1]

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The use of IBM machines facilitates the recording, organizing, and computation of research data. A plan was developed for recording and processing data obtained in a preservative study in which small stakes were used. The methods are adaptable to other investigations involving wood products.

THE RECORDING, ORGANIZATION, AND COMPUTATION of research data are only a part of the investigator's job, but they are highly important parts. Inefficient methods sap the researcher's productive capacity, add to the cost of the investigation, and may increase the size of the study's experimental error.

Although this report describes the recording and processing of data collected from a stake-test of wood preservatives with International Business Machines Corporation (IBM) equipment, the methods can be used, or modified for use, in other investigations involving wood products.

Approximately 1,400 southern yellow pine and eastern white pine stakes 2 x 2 inches in cross-section and 2 feet in length were treated with 35 preservative formulations. The treating methods consisted mainly of 24-hour cold soak and a 48-hour cold soak, although 18 stakes were given a liberal brush treatment with preservative liquids.

The treated stakes were set in a "graveyard," together with untreated control stakes at the Dixon Springs Experiment Station in southern Illinois in December 1947. Each stake has been inspected annually since then for indications of attack by insects and fungi. At five-year intervals the stakes are placed in a holder and stressed as a cantilever beam. Both inspection and treating data have been recorded and processed with IBM machines.

Record Cards

Fig. 1 shows a typical IBM card, 3¼" x 7⅜", which has been used to record treating and service data. Fig. 2 shows a "mark sense" card that has been overprinted for use as an annual inspection card.

Because the cost of printing headings on IBM cards is rather expensive, it probably will be more economical to multilith them. For example, the cost of printing 6,000 cards with the headings shown in Fig. 2 is estimated to cost $40, whereas the same headings could be multilithed for about $15. Plastic templates may be used in lieu of printed headings.

The standard IBM card (Fig. 1) has 80 columns of digits that run from 0 to 9. In addition to these 800 positions for data, the card has two rows of 80 positions located near the top of the card, which are designated as "X" and "Y" positions. The X and Y positions are not identified with numbers as are the main positions on the card. Thus each card has 960 places in which data may be recorded.[2]

Only part of the right-hand half of the card shown in Fig. 2 is printed for mark-sense data. Note that each mark-sense position, or cell, has a number in the middle of it and that one mark-sense position covers three "punch positions" on the standard card.

Alphabetical data may be coded and tabulated by combining the X and Y punches with numbers. For example, a Y punch in the same column with a 0 punch means A.

There are a number of styles and colors of cards, but all have about the same fundamental design. The cards are rather inexpensive, costing about $2 per thousand. Two thousand cards, with space for recording approximately 2 million figures, occupy a box about 3½" x 8" x 14½".

Computing and Tabulating Equipment Used

A number of machines are needed to process data by the IBM system. All of them are complicated and expensive. They can be leased at rates ranging from $10 to $20,000 per month. Most types are available for rental, however, at several hundred locations in the United States at "job" rates that are relatively inexpensive. The following description of IBM equipment is general, because there are several models of each type of machine.

Printing Punch Machine: This typewriter-like machine transfers measurement or enumeration data to the record cards in the form of small rectangular (usually) holes about 1/16" x 1/8" and prints them along the upper margin. The holes, which may be seen in Fig. 2, permit the closing

[1] Presented at Session IV, Smog Control, Electric Drives, and Wood Preservation, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

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[2] The cards have other positions for recording information, but these 960 positions are the ones that are most commonly used and the only ones that were used in this project.

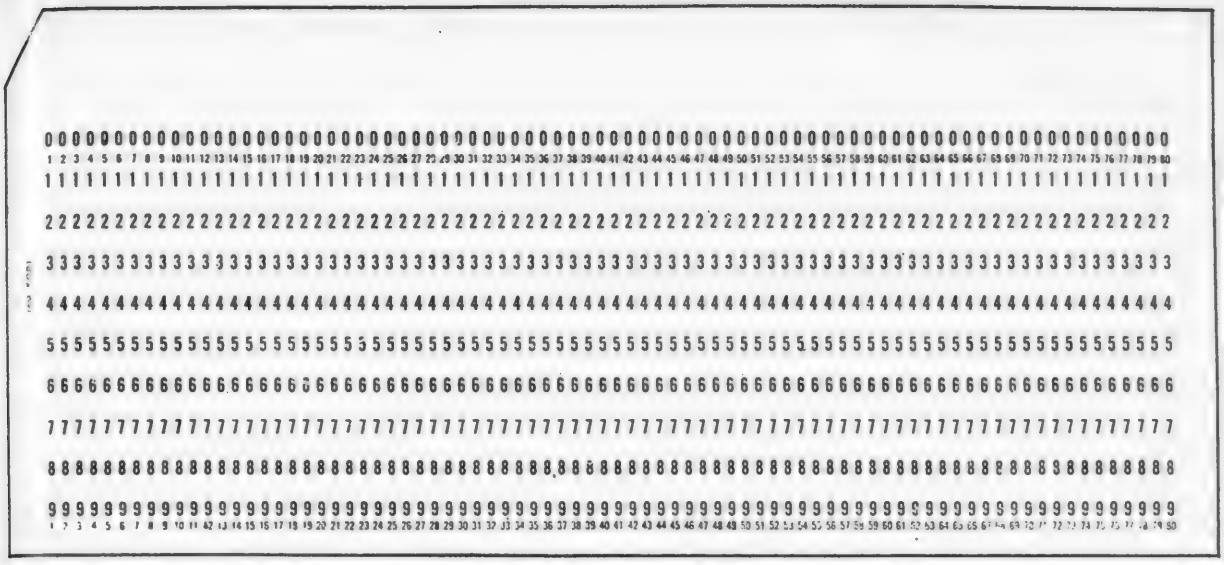

Fig. 1.—A standard IBM card.

of the electrical circuits that operate the various sorting, computing, and tabulating machines. Often one may want to reserve space on the card for data that are to be collected at some future date. It is better practice to punch data continuously and leave the blank spaces at the end rather than to skip spaces, because skipping makes it more difficult for the operator to punch the cards and increases the possibility for punching errors.

Verifier: This machine is similar to the punch machine except that it is used to check the data that are punched into the record cards. Thus, if the punch card operator has made a typographical error when punching the data onto the cards, the verifier indicates the error (usually by stopping and flashing a warning light) when the cards are run through the machine in the verifying operation. It is possible, however, for the punch operator to make the same punch error twice. Thus, it is good practice when practicable to have the data on the cards tabulated and the tabulation checked against the original records before starting to compute the data.

Sorting Machines: The investigator usually wants his data organized or sorted into some arrangement before tabulating the information, or he may be interested in only certain groups of measurements. The card-counting sorter sorts the cards at the rate of 440 per minute and tells the investigator how many cards there are in each group. The electronic sorter also sorts cards at the rate of 650 a minute, but it does not count them. A third type of sorting machine, the electric statistical machine, has 60 selectors for counting and can be used for various sorting and counting jobs.

Calculating Punch: The punched cards are run through the calculating punch for such computations as sums, differences, sums of squares, averages, and sums of cross products. The machine punches the calculations on the same data card, or it will punch the results on a separate summary card. Calculations that would require several weeks of hand-operated machine work can be made by the calculating punch in a matter of minutes.

Interpreter: The interpreter tabulates or prints the data punched on a card at some position on the card chosen by the operator, thereby making it easier to read the punched data. The data may be interpreted in an "upper position" or a "lower position," both of which are located near

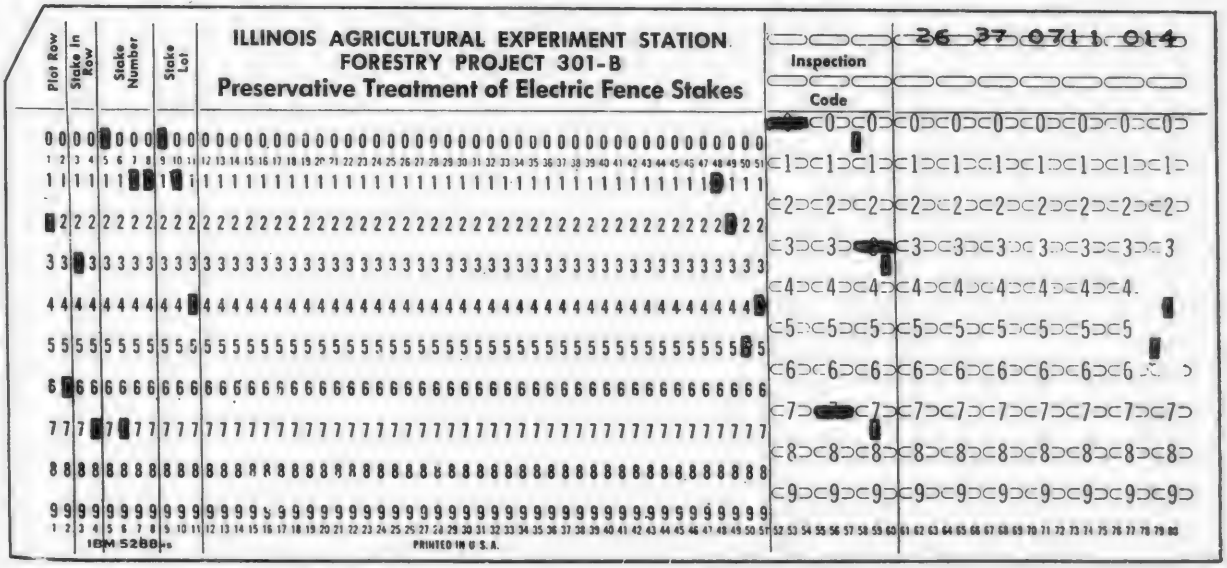

Fig. 2.—An IBM mark-sense card overprinted for use as a field inspection card.

Table 1.—CONDITION OF TREATED AND UNTREATED STAKES BY SPECIES

	Species (12)	Condition class (58–60)	Card Count
E. White Pine	1	000	242
	1	005	130
	1	009	80
	1	017	18
	1	018	13
	1	019	2
	1	021	34
	1	022	3
	1	023	6
	1	024	1
	1	025	15
	1	028	1
	1	039	2
	1	043	3
	1	073	15
	1	089	1
	1	091	1
	1	096	3
	1	097	10
	1	128	4
S. Yellow Pine	2	000	374
	2	005	81
	2	006	1
	2	009	24
	2	017	19
	2	018	6
	2	019	2
	2	021	24
	2	022	2
	2	023	1
	2	025	9
	2	073	14
	2	090	1
	2	096	3
	2	097	5
	2	128	2
Tulip Poplar	3	000	2
	3	005	3
	3	009	2
	3	021	1
	3	025	3
	3	073	3
	3	097	1

Table 2.—CONDITION OF TREATED AND UNTREATED STAKES BY KIND OF TREATMENT

	Soak Period (15)	Condition class (58–60)	Card Count
Controls	0	000	1
	0	005	4
	0	009	2
	0	017	1
	0	021	2
	0	023	1
	0	025	4
	0	073	19
	0	089	1
	0	090	1
	0	091	1
	0	096	1
	0	097	1
24-Hour Soak	2	000	313
	2	005	106
	2	009	46
	2	017	14
	2	018	2
	2	019	1
	2	021	38
	2	022	2
	2	023	3
	2	025	10
	2	043	1
	2	070	5
	2	096	3
	2	097	4
	2	128	6
48-Hour Soak	4	000	300
	4	005	98
	4	006	1
	4	009	57
	4	017	21
	4	018	15
	4	019	3
	4	021	18
	4	022	3
	4	023	3
	4	024	1
	4	025	10
	4	028	1
	4	039	2
	4	043	2
	4	073	5
	4	096	2
	4	097	11
Single Brush Coat	6	000	4
	6	005	6
	6	009	1
	6	017	1
	6	018	2
	6	021	1
	6	025	3

the top of the card. The figures in the upper right-hand corner of Fig. 2 identify the data punched into columns 1 to 11 on the left-hand side of the card. The data are interpreted in the "upper position." For example, they show that in row 26, the 37th stake is Number 711, one of the stakes in Lot 14. The interpreted data are easier to read under field conditions than the punched data.

Electrical Accounting Machine (tabulator): The tabulator prints either punched or calculated data on a long sheet of paper which is automatically fed through the machine. A switch board or control panel similar to a telephone operator's switchboard controls the electrical circuits that operate the machine. Thus it is possible to add and subtract (but not to multiply or divide) figures up to 80 digits which have been punched into cards. The control can be wired so that the data on a card, or a portion of them, are printed with any desired spacing or arrangement on the paper. As many as five legible carbon copies can be made at one time.

When a reproducing punch is connected with an electrical accounting machine, the combination acts as a summary punch. The electrical accounting machine does the computing and transfers the results to the reproducer, which then punches the results on a summary card.

Tables 1 and 2 illustrate the combined use of the two machines. For example, in 1953 a summary of the inspection results was needed after the stakes had been exposed six years. To get this summary, the inspection data for that year were transferred from the mark-sense cards that had been coded in the field (Fig. 2) to columns 58–60 on the treating record card (Fig. 1). The treating record cards were then sorted so that all cards with the same inspection code were grouped for each of three species of wood, and the cards were run through the tabulator (Table 1). The cards were then resorted so that those with the same inspection code were grouped for each of four types of treatments, and a second tabulation was made (Table 2).

In order to interpret the tabulation, one needs a "code sheet' which explains each stake-condition class. The code sheet for the experiment (Table 3) is discussed subsequently, but it may be well to decode a few of the results here to show what had happened to the stakes at the end of six years of exposure. Only one of the control stakes remained sound (000 code in columns 58–60 means that the stake has not been attacked by fungi and insects), whereas 313 stakes soaked 24 hours and 330 stakes soaked 48 hours were sound.

Collator: This versatile machine does many operations, such as merging two sets of cards in some predetermined way, matching cards, or checking the sequences of cards that have been previously sorted into some order by a sorting machine.

Reproducing Punch (reproducer): The reproducer has several functions. One important function is to transfer mark-sense data to punched form. In Fig. 2 three of the mark-sense positions under "Inspection Code" are shown as black spots. These three positions were coded and filled in with a black carbon pencil in the field. The coded cards were then run through the reproducer. When small "fingers" in the reproducer contacted the carbon spots, electrical circuits were closed and the machine punched the coded data onto the card. (Note the rectangular hole punched below each mark-sense position in columns 58–60.) The inspection data in Fig. 2 were coded as 073, indicating that stake No. 171 failed in 1954 from advanced decay in the butt.

The reproducer punches identifying data on a series of cards, or it can transfer such data from one position on a master card to another position on a different card. It can "gang" punch, or punch a series of cards from one master card. For example, each year a new deck of inspection cards is prepared from the previous year's deck. The reproducing punch punches the identifying data (plot, row, stake in row, stake number, and stake lot in Fig. 2) into the new deck in a few minutes. The cards are then sorted so that they are in the same order in the deck as the inspector will find the randomized stakes in the test plot.

Coding Data

Both measurement and enumeration data can be recorded and processed by IBM methods. The working plan for the investigation, however, must include a schedule or code sheet which shows the various measurements to be made and shows how easy they are identified and located with regard to almost 1,000 positions on the record card. In other words, the code sheet is the identification key to the information recorded on the cards.

Table 3 shows the code sheet for stake-test data. Note that "blanks" are used to indicate "no measurement made," as well as to record an observation of some type such as "unable to determine percentage." Each number or combination of numbers on the card shows the results of a measurement or observation enabling the

reader to decode the information shown in the figures and tables.

As mentioned earlier, the stake represented by the card in Fig. 2 was coded 073 in columns 58–60. The code illustrates the possibilities of a geometric code, in which several variables may be combined and the sum of their identification numbers punched into the card. For example, the classification 073 was determined as follows:

001 = butt
008 = advanced decay
064 = failed

Total 073

If insects had contributed to the failure, that information would have been included in the code by adding 016, the code for insects, to 073. The total, 089, would classify a stake that had failed in the butt from advanced decay and insects. This combination of codes is the only one that will total 089; thus the proper classification of the condition of that particular stake is assured.

The American Wood-Preservers' Association has prepared the following methods of coding stake condition.[3]

	25 per cent depreciation system	Log base scale
Decay grades		
Sound—no evidence of decay	100	100
Localized superficial decay	75	90
Slight but positve decay	50	70
Deep or severe decay	25	40
Failure—almost complete loss of strength	0	0
Termite grades		
No attack	100	100
Slight attack	75	90
Moderate attack	50	70
Severe attack	25	40
Failure caused by termites	0	0

Both systems can be processed by IBM methods.

Ordinarily, measurement data are coded only in the 0–9 positions on the card. The X and Y positions are used to code such information as "X punch in column 30 indicates presence of mold on stake at time of treatment" or some similar observation.

Although the transformation of data, as from a measurement to its logarithm, technically is not "coding," the IBM method facilitates the use of this statistical tool. The "log deck," cards containing the logarithms of numbers, enables the machines to "look up" the logarithm or antilog of measurements in a fraction of the time required when the investigator uses tables. If the log transformation is found to be unsatisfactory, angular, reciprocal, square root, or other types of transformations can be quickly made and tested by the machines.

[3] Report of Committee P-6, Methods for the Evaluation of Wood Preservatives. 1954. Proc. Am. Wood Preservers' Assoc. 50: 107-111.

Table 3.—CODE SHEET FOR STAKE-TEST DATA PUNCHED INTO IBM CARDS

Card column	Coded data
1– 2	Stake row in plot. Row 1 is located at north end of plot.
3– 4	Stake in row. First stake is on west side of row.
5– 8	Stake number. Numbers from 1 to 1411 are on tag at top end of stake.
9–11	Stake lot 001—Lot A-1 002—Lot A-2 120—Lot MM-1
12	Species. Eastern white pine, 1; southern yellow pine, 2.
13–14	Moisture content, per cent. 00 means no measurement taken.
15	Method of treatment 0—not treated (control) 2—cold soaked 24 hours 4—cold soaked 48 hours 6—brushed on one coat
16–18	Volume in cubic feet. Drop one decimal place to .000 on card, but read as 0.0000. If 000 and Col. 15 shows treatment, the data have not been used in computations because they have been classified as "outliers." Some of these stakes were set in test plot.
19–21	Specific gravity. Read as .000.
22–23	Growth rings per inch. Read as "xx"; 00 means no measurement.
24–25	Preservative 00 —Control stake, no preservative used 01–09—Pentachlorophenol 10–19—Mixtures of chlorinated phenols 20–29—Copper naphthenate 30–39—Other oil-soluble naphthenates 40–49—Phenyl mercury oleate 50–59—Coal tar distillates 60–69—Miscellaneous preservatives not otherwise classified
26–28	Weight, untreated. Read as 0.00 pounds.
29–31	Weight, treated. Read as 0.00 pounds.
32–35	Absorption of solution in pounds per cubic foot of wood. Read as 00.00. Wire five digits in control board for totals.
36–39	Average absorption for lot in pounds per cubic foot. Read as 00.00.
40–42	Sapwood content. Per cent of total stake except for following: 222—mostly heartwood 333—mostly sapwood 999—no measurement
43–45	Penetration of sapwood in inches. Read as x.xx 0.00—indistinguishable blank—no measurement
46–48	Per cent of sapwood penetrated 000—indistinguishable blank—unable to determine percentage
49–50	Penetration of heartwood in inches .00—indistinguishable blank—unable to determine percentage
51–53	Per cent of heartwood penetrated 00—indistinguishable blank—no measurement
54–55	Date set, month (December)
56–57	Date set, year (1947)
58–59	Inspection code for 19----

Advantages of IBM System

The IBM system is a time-saving technique, especially when the design of the study lends itself to complete statistical analysis. Regression formulae or the components of an analysis of variance can be calculated in a matter of minutes after the cards have been punched. Time can be saved by recording measurements or observations on mark-sense cards at the time they are made, instead of having to punch them into cards later. For example, the organization and computation of field inspection data that once required about two weeks to complete can now be done with IBM machines in about two hours.

Once the data are recorded on IBM cards, they can be manipulated more easily than by almost any other system. They can be transferred to other cards, computed, listed, reproduced, or classified in a variety of ways at a fraction of the time the investigator would need to do the job by almost any other method.

One of the major benefits accruing from the use of the IBM technique is that it forces the investigator to plan for all details of the study. The machine is solely mechanical, and its guidance depends upon the wishes of the researcher. Thus, if the researcher wants certain information at the end of the study, he must design the investigation and record cards so that he can obtain the information he wants. In this highly analytical process, he is called upon to decide many issues that he might not have considered under more commonly used research methods.

The swiftness with which the IBM punch-card machines can organize and compute data continually amazes those who use them. They can be used to record and organize data for computation on the newer electronic digital computers. Information is read into the computers at a rate exceeding 500 decimal digits per second by means of photoelectric cells that scan a punched paper tape. Vacuum tubes, magnetic memory drums, and electric typewriters transfer complex calculations to printed tabulations in fractions of seconds. For example, the basic addition of two decimal digits is done on some machines at the rate of 70,000 times per second. Thus, a complicated analysis of variance for a multilevel factorial problem can be tabulated complete with table headings in a matter of minutes. These machines are expensive, and at present there are only a few of them, but they can be used to solve the more complex mathematical problems.

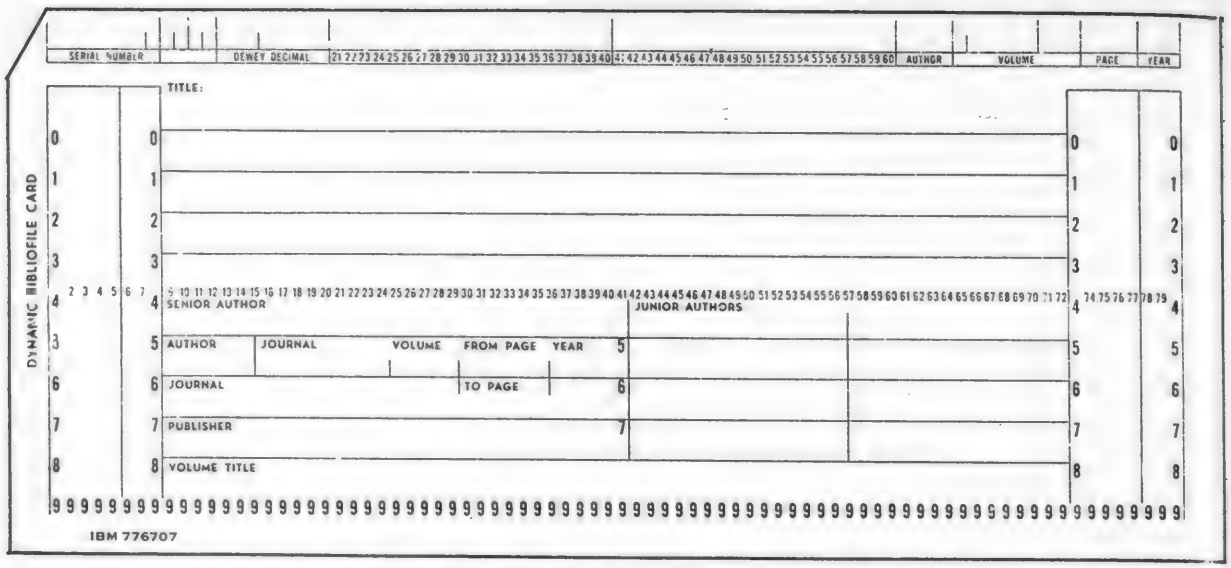

Fig. 3.—Literature reference card. Coded citation data punched on the card enables the investigator to sort cards with IBM equipment and to speed up and simplify the review of classified literature.

Practically every investigator has had difficulty in classifying reference material by some practicable scheme. As more bulletins and reports are collected, the task of classifying them so that they can be found when needed becomes more difficult. Every researcher probably revises his classification system two or three times before the collection of references finally becomes too large to reclassify. The IBM system can be used to review literature easily and efficiently. For example, Dr. D. M. Hall, Assistant Professor of Agricultural Extension, University of Illinois, has developed a system which files each of his references in a consecutively numbered order. An IBM card prepared for each reference (Fig. 3) shows the Dewey decimal classification, author, journal, and classification data.

Forest products references might be identified by the Yale decimal system for classifying forestry data or by a modification of the system. Thus, a review of the literature would be initiated by sorting the deck of reference cards to group those concerning the particular field of interest. If the reference deck contained 3,000 titles, it would require less than five minutes to extract all cards concerning this field. The cards would show the location of the various reports in the library.

Disadvantages of the IBM System

Some researchers may not have the expensive IBM machines readily available for their use. However, several hundred IBM offices located in the United States offer consulting services and facilities for custom work.

The machine designers have made every effort to eliminate errors. As a result, most of the errors that develop are human ones. The errors that do develop are much harder to detect than those in data that are scanned several times during ordinary processing.

Highly trained personnel are needed to operate and maintain the machines. It is a waste of the investigator's time to learn more than a few of the simplest details of operation. For example, wiring the control boards may be compared to tracing the circuits in a television set. When our television sets get out of order, most of us take them to an expert. IBM machines are so complicated that the best results can be obtained with them when they are operated and maintained by skilled technicians.

Discussion

G. G. Garlick (Protection Products Mfg. Co.): You don't have to keep these machines at your operation. You can send the cards to an IBM office for analysis.

Mr. Walters: Yes, there usually is IBM equipment available at a nearby office, university, or other facility, making it unnecessary to invest in this expensive equipment.

E. A. Behr (Chapman Chemical Co.): Do you have to record data on these cards in the field?

Mr. Walters: We record stake inspection data in the field on the mark-sense cards. Sometimes it is inconvenient—inclement weather, for example—but usually a satisfactory means of doing the job can be devised. Recording data in the field on mark-sense cards eliminates one source of error, the transferring of inspection data from field sheets to punched cards. Thus, the system not only is more accurate, but also it saves time.

Pentachlorophenol Gradients in Pressure Treated Wood Under Exposure to Weather[1]

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Describes the effect of various solvents for pentachlorophenol on its distribution and permanence in wood after pressure treatment by an empty-cell schedule. Both round and rectangular stock of southern yellow pine and rectangular Douglas-fir were treated. Solvents were medium aromatic gas oil, aromatic kerosene, and xylene. A limited amount of southern yellow pine and Douglas-fir was treated with a coal tar creosote for comparative purposes.

Introduction

BEHAVIOR OF PRESERVATIVES after they have been impregnated into wood is an important aspect of wood preservation. Study of the concentration of the preservative chemical at varying distances from the exterior of a piece of impregnated wood leads to better planning of retentions and schedules. The effect of varying exposure on change in the gradient can be found. Likewise, where oil-borne preservatives are involved, the effect of the solvent carrier on the change in the preservative gradient can be measured. The rate of loss of preservative can be followed, and perhaps a predication of time of replacement made.

The work described herein was undertaken to study the effect of various solvents for pentachlorophenol on its distribution and permanence in pressure treated wood. In addition, a few coal tar creosote treatments were included for comparative purposes. Both round and rectangular stock were considered.

Past Investigations

The most extensive work to date[2] showing initial gradients of pentachlorophenol in pressure treated wood was undertaken to accumulate information for a results-type specification for southern yellow pine poles. Another[3] reports primarily on treatments of Douglas-fir and southern yellow pine lumber using pentachlorophenol in volatile solvents such as xylene.

In Hudson's work, analyses were made immediately after impregnation and again after a year's weathering. Losses of pentachlorophenol and changes in gradient were attributed to "migration". In the case of one charge of Douglas-fir lumber treated with pentachlorophenol in a medium aromatic gas oil, it would appear that exudation of solution or "bleeding" is most likely the cause. When Hudson described this work, it was not realized that his extracting solvent was not removing all of the pentachlorophenol.

Experimental Materials

The rectangular stock used with the pentachlorophenol treatments consisted of kiln-dried Douglas-fir and southern yellow pine lumber 2 in. by 4 in. by 8 ft. in size. Similar material was used with the creosote treatments except 6-ft. lengths were used rather than 8-ft. lengths. The Douglas-fir lumber contained only heartwood and the pine was all sapwood except for a few boards which contained a small amount of heartwood in the center. Moisture content samples were taken from the boards as purchased. The moisture content of both species was between 8 and 12 per cent and averaged 10 per cent for all boards.

The round stock was class 6, 25-foot, machine peeled and unseasoned southern yellow pine poles.

The solvents used were: xylol; an aromatic kerosene known by the refinery as Heavy Thermal Sidecut[4]; and an aromatic gas oil called Aromatic HB[5]. Typical characteristics of these solvents are shown in Table 1.

A coal tar creosote conforming to American Wood Preservers' Association Specification P1-54 was used on a few charges of rectangular stock for comparisons. It had a residue above 355° C. of 19.5 per cent. The analysis will be found in Table 1.

[1] Presented at Session IV, Smog Control, Electric Drives, and Wood Preservation, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

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Robert E. Hill, Jr., received B.S. in chemistry from Memphis State College in 1950, joined Chapman Chemical Co. as chemist in 1951.

[2] Lumsden, G. Q. and Committee. 1952. Report of Committee T-2. AWPA Proceedings, 48: 175-191.

[3] Hudson, M. S. 1953. Recovery of solvent from wood pressure treated with oil-borne preservatives and its effect on paintability. AWPA Proc. 49: 146-171.

[4] Produced by Pan Am Southern Corporation, El Dorado, Ark., and sold to wood treating industry as 105E.

[5] Produced by Enjay Co., Baton Rouge, La.

Table 1.—CHARACTERISTICS OF SOLVENTS AND COAL TAR CREOSOTE USED IN TREATMENT

Solvent Name	Xylene	105E	Aromatic HB
Gravity at 60°F., API°	31.5	38	18.8
Flash Point, PMCC, °F.	80*	150	230
Viscosity at 100°F. SUS	0.744†	32	37.8
Distillation, ASTM, °F.			
Initial Boiling Point	278	360	425
10%		424	488
50%	281	452	530
90%	284	488	569
Final Boiling Point	290	583	610
Pentachlorophenol Solvency at 75°F., %	18	12	15

*Tag Closed Cup.
†Viscosity at 25°C., centistokes.

	Creosote
Specific Gravity 60/60	1.08
Viscosity, SUS, 210°F.	31.6
Distillation (AWPA, A1-51) per cent	
up =to 210°C	none
up to 235° C	18.5
up to 270° C	29.0
up to 315° C	17.5
up to 355° C	16.5
Residue	19.5

Table 2.—TREATING SCHEDULES AND RESULTS OF TREATMENTS

Charge No. (1)	Species (2)	Type of Material (3)	Total Volume (cu. ft.) (4)	Impregnating Solution (5)	Impregnation				Vacuum after Impregnation		Final Steaming			Vacuum after Steaming		Net Retention[1] (lb./cu. ft.) (18)
					Initial Air Pressure* (psi) (6)	Maximum Preservative Pressure (psi) (7)	Time to Maximum Pressure (minutes) (8)	Time at Maximum Pressure (minutes) (9)	Average Preservative Temperature (°F.) (10)	Maximum (in. Hg.) (11)	Duration (minutes) (12)	Time to Maximum Temperature (minutes) (13)	Maximum Temperature (°F.) (14)	Time at Maximum Temperature (minutes) (15)	Maximum (in. Hg.) (16)	Duration (minutes) (17)	
240	Douglas-fir	2 x 4's	1.587	Aromatic HB-Pentachlorophenol	50	125	120	60	197	28	30	60	240	30	28	60	7.25
241	Douglas-fir	2 x 4's	1.595	Aromatic HB-Pentachlorophenol	50	125	120	60	197	28	30	60	240	30	29	60	7.65
201	Douglas-fir	2 x 4's	1.889	Aromatic HB-Pentachlorophenol	50	125	120	60	196	28	30	60	240	30	26	45	9.28
202	Douglas-fir	2 x 4's	1.866	Aromatic HB-Pentachlorophenol	50	125	120	60	196	28	30	60	240	30	26	45	8.04
245	So. Pine	2 x 4's	1.574	Aromatic HB-Pentachlorophenol	30	150	30	20	192	27	30	60	260	60	27	60	10.39
203	So. Pine	2 x 4's	1.138	Aromatic HB-Pentachlorophenol	35	150	30	20	193	28	30	60	260	60	27	60	8.37
204	So. Pine	2 x 4's	1.133	Aromatic HB-Pentachlorophenol	35	150	30	20	193	28	30	60	260	60	27	60	6.41
247	Douglas-fir	2 x 4's	1.511	105E-Pentachlorophenol	50	125	120	40	198	27	30	60	240	30	27	60	8.44
246	So. Pine	2 x 4's	1.575	105E-Pentachlorophenol	40	150	30	20	194	27	30	60	260	60	27	60	8.89
252	Douglas-fir	2 x 4's	1.547	Xylene-Pentachlorophenol	50	125	120	40	99	27	60	- -	- -	- -	- -	- -	7.92
256	So. Pine	2 x 4's	1.528	Xylene-Pentachlorophenol	40	150	30	20	98	27	30	- -	- -	- -	- -	- -	7.36
287	Douglas-fir	2 x 4's	1.184	Coal Tar Creosote	50	125	120	60	199	27	30	60	240	60	26	60	7.39
288	Douglas-fir	2 x 4's	1.094	Coal Tar Creosote	50	125	120	60	199	27	30	60	240	60	26	60	8.08
289	So. Pine	2 x 4's	1.133	Coal Tar Creosote	40	150	30	30	192	27	30	60	260	60	26	60	14.34
290	So. Pine	2 x 4's	1.137	Coal Tar Creosote	40	150	30	30	192	27	30	60	260	60	26	60	10.55
250[2]	So. Pine	Poles	9.90	Aromatic HB-Pentachlorophenol	30	150	30	30	200	27	30	- -	- -	- -	- -	- -	ND
251[2]	So. Pine	Poles	0.44	Aromatic HB-Pentachlorophenol	50	150	30	30	198	26	30	- -	- -	- -	- -	- -	ND

*Initial air pressure held on southern pine and Douglas-fir for 1 and 15 minutes, respectively, prior to filling cylinder with preservative.

[1]Net retention given is that determined by weighing each charge before and after treatment.

[2]These charges were steam-conditioned prior to treatment. The steam temperature was raised to 280°F. over a 60-minute period and held at this level for 5 hours. The steaming period was followed with a 60-minute vacuum.

Experimental Methods

Douglas-fir and Southern Pine Boards: Each charge for treatment consisted of five boards. The boards were weighed and measured prior to treatment. These data were used to calculate the kiln-dry volume and density of each board at the time of treatment.

At least one charge of each species was impregnated with each of the solvents listed in Table 1. Prior to impregnation, 5.1 per cent by weight of technical pentachlorophenol was dissolved in each solvent. All treatments were accomplished with an empty-cell schedule. Data obtained during the treatment of each charge are given in Table 2.

Each charge was removed from the cylinder immediately following the final vacuum and its five boards weighed individually. A 1-inch section along the grain was removed from the middle of each board for analysis by zones. After removal of the analysis section, the two remaining 4-foot pieces were weighed separately and one was suspended over sawdust in the laboratory and the other placed on a test fence for exposure to the weather. The piece retained in the laboratory was weighed at daily intervals for the first 30 days. At each weighing, each piece was examined for the presence of bleeding and/or blooming.

At the end of the first 30 days following treatment, the pieces on the test fence were returned to the laboratory for analysis and the pieces retained in the laboratory during this period were placed on the test fence and allowed to weather for 11 months before being removed for analysis. Upon removal from the test fence each piece was weighed and a section 8 inches long along the grain was cut from the end nearest the center of the original 8-foot board and discarded. A 1-inch section was then taken from the fresh-cut end of each piece for analysis.

The procedure employed for the analysis of the sections taken immediately after treatment and 30 days and 12 months after treatment and exposure was similar except for one variation, which will be discussed later. The surface of each section for analysis was scraped thoroughly with a dull knife to remove any residual surface deposits. After the surface was scraped, each section was separated into the following zones for analysis: outer ¼-inch; second ¼-inch; and remainder or core. The zones were separated by sawing with a band saw.

Prior to chipping for analysis, a piece ¼-inch long along the grain was removed from each end of each zone and discarded. This procedure was followed in order to eliminate the possibility that solution had spread over the end of the section before the zones were separated. The wood remaining from each zone (½-inch along the grain) was chipped into small pieces by means of a heavy slicing device.

The chips from each zone were weighed and placed in a soxhlet extractor for extraction with toluene. The water was collected in a trap during the first part of the extraction period and measured. The toluene extract obtained from each zone was concentrated and analyzed for pentachlorophenol by the lime ignition method and the extracted wood chips were placed in an oven and dried to a constant weight at 220° F.

A 4-gram sample of the extracted and oven-dried chips remaining from the pieces analyzed after an exposure period of 12 months was ashed to determine the amount of residual pentachlorophenol remaining after extraction with toluene.[6] The chips remaining from the analyses made immediately and 30 days after treatment, however, were not checked for residual pentachlorophenol after extraction because it was not known during this phase of the project that toluene would not extract all of the penta from wood which had been steamed after treatment.

The amount of solution extracted from the chips was determined by subtracting the oven-dry weight from the original weight to obtain the total loss during extraction, and subtraction of the amount of water removed from this value gave the amount of solution present in the chips before extraction. These values for solution and pentachlorophenol were expressed as per cent of the oven-dry weight of the extracted wood and later converted to pounds per cubic foot based on the oven-dry density of each board.

The actual retention of solvent was determined by subtracting the pentachlorophenol content from the solution content. The solvent retention by this method, of course, is not precise because of the natural wood extractives that are moved along with the pentachlorophenol solution during extraction.

The analytical procedure with the boards treated with coal tar creosote was similar to that described for the pentachlorophenol treatments. Samples were taken from the untreated boards for extraction with toluene to determine the amount of extractives present before treatment. The extractive content before treatment was subtracted from that found after treatment by

[6] The extract and chip analyses conformed to AWPA Standard A5-54.

Table 3.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN DOUGLAS-FIR 2- BY 4-INCH BOARDS IMMEDIATELY AFTER PRESSURE TREATMENT AND AFTER EXPOSURE ON A TEST FENCE FROM 30 DAYS TO 12 MONTHS

Charge No (1)	Number of Boards (2)	Treating Solution (3)	Type of Impregnating Schedule (4)	When Analyzed After Treatment (5)	Distribution of Pentachlorophenol in Cross-Section† (lbs./cu. ft) Outer ¼-Inch (6)	Second ¼-Inch (7)	Core (8)	Weighted Average Cross-Section (9)	Distribution of Solvent in Cross-Section (lbs./cu. ft.) Outer ¼-Inch (10)	Second ¼-Inch (11)	Core (12)	Weighted Average Cross-Section (13)
240	4	Aromatic HB-Pentachlorophenol	E-C* Final Steam	12 Hours	0.438	0.212	0.138	0.290	8.64	4.19	2.04	5.54
240	4	Aromatic HB-Pentachlorophenol	E-C* Final Steam	30 Days	0.429	0.164	0.114	0.264	7.45	3.15	1.88	4.62
240	4	Aromatic HB-Pentachlorophenol	E-C* Final Steam	12 Months	0.416	0.169	0.125	0.263	4.77	1.49	0.74	2.69
241	5	Aromatic HB-Pentachlorophenol	E-C, Final Steam	Immediately	0.358	0.260	0.195	0.285	7.13	4.78	3.35	5.42
241	5	Aromatic HB-Pentachlorophenol	E-C, Final Steam	30 Days	0.440	0.125	0.101	0.252	7.06	2.09	0.97	4.07
241	5	Aromatic HB-Pentachlorophenol	E-C, Final Steam	12 Months	0.432	0.141	0.085	0.251	5.21	0.89	0.88	2.76
247	5	105E-Pentachlorophenol	E-C, Final Steam	Immediately	0.397	0.241	0.163	0.287	7.26	4.47	2.90	5.27
247	5	105E-Pentachlorophenol	E-C, Final Steam	30 Days	0.402	0.145	0.115	0.246	4.32	3.37	2.55	3.57
247	5	105E-Pentachlorophenol	E-C, Final Steam	12 Months	0.430	0.157	0.148	0.270	2.04	1.80	0.59	1.60
252	4	Xylol-Pentachlorophenol	E-C, No Final Steam	Immediately	0.421	0.286	0.210	0.324	4.80	3.36	2.58	3.77
252	4	Xylol-Pentachlorophenol	E-C, No Final Steam	30 Days	0.367	0.080	0.064	0.197	1.10	0.68	1.27	1.01
252	4	Xylol-Pentachlorophenol	E-C, No Final Steam	12 Months	0.342	0.095	0.087	0.198	1.09	1.33	1.16	1.19

*E-C = Empty-Cell Treatment.
†Pentachlorophenol retention shown after 12 months' exposure includes residual pentachlorophenol found in extracted chips as shown in Table 5.

toluene extraction to determine the actual retention of creosote.

The oven-density of the extracted chips remaining from the samples analyzed before and after treatment was compared as a means of assuring that the toluene removed all of the creosote. The density of the extracted chips was determined by the water immersion method after a known weight of oven-dry chips was given a full-cell treatment with water so that all chips were heavier than water. Data obtained during the treatment of the creosote charges are given near the bottom of Table 2.

Southern Pine Poles: Each pole was prepared for treatment by cutting a 6-foot section from the butt end and discarding it along with a 1-foot section cut from the top end. The length of each pole and its diameter at each end was determined prior to impregnation. These measurements were used for green volume determination. Only the solution composed of 5 per cent pentachlorophenol in Aromatic HB oil was used on the poles. Each charge consisted of two 18-foot poles, and an empty-cell schedule was used for impregnation. Each charge of poles was steam-condtioned prior to impregnation with preservative. Treating data for the poles are given at the bottom of Table 2.

Each charge of poles was removed from the cylinder immediately following the final vacuum and each pole was cut in the middle and a 2½-inch disc removed for analysis for moisture, pentachlorophenol, and solvent content by zones. The resulting 9-foot pieces were placed in the ground to a depth of 19 inches from the end opposite the fresh-cut end.

At the end of the first 6 months after treatment, a piece 12 inches long along the grain was cut from the top of one of the pieces from each original 18-foot pole and discarded. A 2½-inch disc was then cut from the top of each fresh-cut piece and zoned for analysis. The remaining piece from each original 18-foot pole was sampled for analysis in a similar manner 18 months after treatment.

The procedure employed for the analysis of the pole discs taken immediately, 6 months, and 18 months after treatment was identical except as herewith noted. The diameter of each disc was determined and its depth of sapwood measured and recorded. Each disc was then marked and split into the following zones for extraction and analysis: outer ½-inch; second ½-inch; second 1-inch; and third 1-inch from the surface. The portion inside the third 1-inch from the surface of each disc was discarded.

As with the 2-by 4-inch sections, after the pole discs were zoned a piece ¼-inch long along the grain was removed from each end of each zone and discarded in order to eliminate the possibility that solution had spread over the end grain between the time the discs were cut and separated into zones for analysis. The discs cut immediately and 18 months after treatment were extracted with toluene only, but a combination of toluene and methyl alcohol[7] was used to extract the discs cut 6 months after treatment. With the latter extractions, toluene was used until all of the water had been removed from the chips. The water was measured and the toluene was boiled off and replaced with methyl alcohol to complete the extraction process. The extracted chips were dried in an oven and weighed. A 4-gram sample of the oven-dried chips from each zone of the discs cut 6 months and 18 months after treatment was analyzed for residual pentachlorophenol content.

The pentachlorophenol found in the extracted chips was added to that found by analysis in the extracts. The density of the extracted chips from each zone of the discs cut 6 months after treatment was determined based on the green volume and oven-dry weight of the extracted chips. The green volume of the chips was determined by the water immersion method after the extracted and oven-dried chips had been given a full-cell treatment with water so that all of the chips were heavier than water.

The pentachlorophenol content of each zone was converted to pounds per cubic foot based on the density of the discs cut 6 months after treatment. The density of the extracted chips from the discs cut immediately and 18 months after treatment was not determined since the three discs cut from each pole were within two feet of each other.

[7] Extensive tests showed that this combination removed substantially all of the pentachlorophenol from wood by the extraction procedure applied.

Experimental Results

Douglas-fir and Southern Pine Boards: The results obtained from the extraction sections taken from the Douglas-fir boards are presented in Table 3. Similar data for the southern pine boards are contained in Table 4. The results for the moisture content determinations are not given in the above tables since the moisture content for all boards was uniform. The weighted average given in the tables for each charge is based upon the actual area that each zone analyzed occupied in relation to that of the entire cross-section. These values for each species of wood were as follows:

Zone Analyzed	Per cent of Cross-Section: Douglas-fir	Southern Pine
Outer ¼-inch	42.34	42.62
Second ¼-inch	32.85	33.21
Remainder or Core	24.81	24.17
Total	100.00	100.00

As indicated previously, the sections extracted with toluene immediately and 30 days after treatment were not checked for residual pentachlorophenol content after extraction, whereas the sections extracted after an exposure period of 12 months were analyzed

Table 4.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN SOUTHERN PINE 2- BY 4-INCH BOARDS IMMEDIATELY AFTER PRESSURE TREATMENT AND AFTER EXPOSURE ON A TEST FENCE FROM 30 DAYS TO 12 MONTHS

Charge No (1)	Number of Boards (2)	Treating Solution (3)	Type of Impregnating Schedule (4)	When Analyzed After Treatment (5)	Distribution of Pentachlorophenol in Cross-Section† (lbs./cu. ft.) Outer ¼-Inch (6)	Second ¼-Inch (7)	Core (8)	Weighted Average Cross-Section (9)	Distribution of Solvent in Cross-Section (lbs./cu. ft.) Outer ¼-Inch (10)	Second ¼-Inch (11)	Core (12)	Weighted Average Cross-Section (13)
245	5	Aromatic-HB-Pentachlorophenol	E-C*Final Steam	Immediately	0.625	0.369	0.297	0.461	13.53	8.91	6.04	10.19
245	5	Aromatic-HB-Pentachlorophenol	E-C*Final Steam	30 Days	0.709	0.297	0.187	0.446	13.82	6.94	4.53	9.29
245	5	Aromatic-HB-Pentachlorophenol	E-C*Final Steam	12 Months	0.896	0.408	0.313	0.593	12.48	7.12	5.35	8.97
246	5	105E-Pentachlorophenol	E-C, Final Steam	Immediately	0.606	0.360	0.279	0.445	10.93	7.46	5.82	8.54
246	5	105E-Pentachlorophenol	E-C, Final Steam	30 Days	0.700	0.248	0.193	0.428	8.71	5.49	4.90	6.72
246	5	105E-Pentachlorophenol	E-C, Final Steam	12 Months	0.615	0.284	0.247	0.416	3.89	2.91	2.95	3.33
256	5	Xylol-Pentachlorophenol	E-C, No Final Steam	Immediately	0.506	0.359	0.332	0.415	6.87	5.16	4.11	5.63
256	5	Xylol-Pentachlorophenol	E-C, No Final Steam	30 Days	0.491	0.155	0.123	0.290	1.85	1.97	2.29	1.89
256	5	Xylol-Pentachlorophenol	E-C, No Final Steam	12 Months	0.526	0.217	0.187	0.341	1.78	0.50	1.27	1.24

*E-C = Empty-cell treatment.
†Pentachlorophenol retention shown after 12 months' exposure includes residual pentachlorophenol found in extracted chips as shown in Table 5.

for residual pentachlorophenol content. Table 5 contains the residual pentachlorophenol retentions found in the sections extracted with toluene after an exposure period of 12 months. These values are included in the retentions given in Tables 3 and 4 for the 12-month analyses.

Obviously, if the results shown for the analyses immediately and 30 days after treatment are lower than actual due to residual pentachlorophenol in the chips after extraction with toluene, then the amount of pentachlorophenol lost during the first 12 months after treatment is greater than indicated in Tables 3 and 4. Since the presence of residual pentachlorophenol in the extracted chips from the sections analyzed immediately and 30 days after treatment would limit any conclusions drawn from the data in Table 3 and 4, two additional charges of each species were treated to determine the approximate amount of residual pentachlorophenol remaining in the sections analyzed immediately and 30 days after treatment. The results for these charges are presented in Tables 6 and 7.

Table 6 contains the distribution of pentachlorophenol and solvent in the charges immediately and 30 to 43 days after treatment. The residual pentachlorophenol found in each charge after extraction with toluene is shown in Table 7. The values in the latter table are included in the pentachlorophenol retentions shown in Table 6

Southern Pine Poles: The pentachlorophenol and solvent retentions found in the discs are given in Table 8. The weighted average given for each pole is based upon the actual area that each zone analyzed occupied in relation to the total area of the cross-section included in the analyses. In other words, that area inside the third 1-inch from the pole surface was disregarded in computing the weighted average. The average at the bottom of the table was obtained by averaging the results for each individual pole.

Table 6.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN 2- BY 4-INCH BOARDS IMMEDIATELY AFTER PRESSURE TREATMENT WITH AROMATIC-HB-PENTACHLOROPHENOL SOLUTION* AND AFTER EXPOSURE ON A TEST FENCE FOR 30 TO 43 DAYS

Charge No. (1)	Number of Boards (2)	Species (3)	Type of Impregnating Schedule (4)	When Analyzed After Treatment (5)	Distribution of Pentachlorophenol in Cross Section (lbs./cu. ft.) Outer ¼-Inch (6)	Second ¼-Inch (7)	Core (8)	Weighted Average Cross Section (9)	Distribution of Solvent in Cross Section (lbs./cu. ft.) Outer ¼-Inch (10)	Second ¼-Inch (11)	Core (12)	Weighted Average Cross Section (13)
291	5	Douglas-fir	E-C†No Final Steam	Immediately	0.420	0.187	0.105	0.265	8.67	4.23	3.25	5.87
291	5	Douglas-fir	E-C†No Final Steam	30 Days	0.286	0.113	0.099	0.183	4.65	2.20	1.63	3.09
292	5	Douglas-fir	E-C, Final Steam	Immediately	0.337	0.202	0.120	0.239	7.80	4.21	2.51	5.30
292	5	Douglas-fir	E-C, Final Steam	30 Days	0.371	0.166	0.138	0.246	5.91	2.70	2.40	3.99
293	5	So. Pine	E-C, No Final Steam	Immediately	0.477	0.307	0.226	0.360	10.27	6.21	4.76	7.59
293	5	So. Pine	E-C, No Final Steam	43 Days	0.595	0.207	0.152	0.360	8.83	3.33	2.88	5.57
294	5	So. Pine	E-C, Final Steam	Immediately	0.496	0.271	0.218	0.354	10.18	4.99	3.88	6.94
294	5	So. Pine	E-C, Final Steam	43 Days	0.525	0.239	0.178	0.346	8.77	4.87	3.21	6.14

*Concentration of pentachlorophenol in treating solution by analysis was 4.74%.
†E-C = Empty-cell treatment.

Table 7.—RESIDUAL PENTACHLOROPHENOL FOUND IN WOOD CHIPS AFTER EXTRACTION WITH TOLUENE IMMEDIATELY AND 30 TO 40 DAYS AFTER TREATMENT WITH A SOLUTION OF AROMATIC HB OIL AND PENTACHLOROPHENOL

No. (1)	Species (2)	Number of Boards (3)	Type of Impregnating Schedule (4)	When Analyzed After Treatment (5)	Residual Pentachlorophenol in Extracted Chips* (lbs./cu. ft.) Outer ¼-inch (6)	Second ¼-inch (7)	Core (8)	Weighted Average Cross Section (9)	Residual Pentachlorophenol in Extracted Chips Expressed as Per cent of Total Amount Present Before Extraction† ¼-inch (10)	¼-inch (11)	Core (12)	Weighted Average Cross Section (13)
291	Douglas-fir	5	E-C‡ No Final Steam	Immediately	0.027	0.013	0.007	0.017	6.43	6.95	6.67	6.65
291	Douglas-fir	5	E-C‡ No Final Steam	30 Days	0.024	0.008	0.007	0.015	8.39	7.08	7.07	7.64
292	Douglas-fir	5	E-C, Final Steam	Immediately	0.048	0.030	0.017	0.034	14.24	14.85	14.17	14.41
292	Douglas-fir	5	E-C, Final Steam	30 Days	0.042	0.017	0.014	0.027	11.32	10.24	10.14	10.67
293	So. Pine	5	E-C, No Final Steam	Immediately	0.010	0.008	0.005	0.008	2.10	2.61	2.21	2.40
293	So. Pine	5	E-C, No Final Steam	43 Days	0.016	0.000	0.006	0.008	2.69	0.00	3.95	2.10
294	So. Pine	5	E-C, Final Steam	Immediately	0.058	0.045	0.041	0.050	11.69	16.61	18.81	15.55
294	So. Pine	5	E-C, Final Steam	43 Days	0.045	0.033	0.032	0.038	8.57	13.81	17.98	12.99

*Determined by analyzing a 4.00-gram sample of the extracted and oven-dried chips.
†Based on total amount of pentachlorophenol present before extraction as given in Table 6.
‡E-C = Empty-cell treatment.

Discussion of Results

Douglas-fir and Southern Pine Boards: Reference to Table 7 indicates that steaming after treatment of either Douglas-fir or southern pine boards increases the amount of pentachlorophenol nonextractable with toluene immediately after treatment. The unsteamed Douglas fir charge indicated only 6.7 per cent residual pentachlorophenol immediately after treatment and extraction with toluene but this was increased to 14.4 per cent for an end-matched charge which was steamed after treatment. In contrast, the unsteamed pine charge indicated only 2.3 per cent residual pentachlorophenol immediately after treatment and similar extraction but this was increased to 15.1 per cent by final steaming.

The data in this table also indicate that an exposure period up to 43 days after treatment did not increase the amount of pentachlorophenol nonextractable with toluene. In fact, slightly less residual pentachlorophenol was found in the sections extracted after exposure than was found in the sections extracted immediately after treatment.

If it is assumed that the data in Table 7 are representative of the effect of steaming on the extractability of pentachlorophenol with toluene, it seems reasonably safe to conclude that the results for the original and 30-day pentachlorophenol analyses given in Tables 3 and 4 for the steamed charges are approximately 15 per cent lower than actual due to residual pentachlorophenol remaining in the chips following extraction with toluene. By the same reasoning, the results for the original and 30-day pentachlorophenol analyses for the unsteamed charges in Tables 3 and 4 appear to be approximately 5 per cent lower than actual.

On the basis that such corrections are legitimate, the results for the original and 30-day pentachlorophenol analyses given in Tables 3 and 4 have been increased accordingly and are presented in Figs. 1 and 2 for the Douglas-fir and southern pine charges respectively. The solvent distribution for each charge is also shown in Figs. 1 and 2. No correction was necessary for the solvent retentions, however, because the portion non-extractable with toluene was small in relation to the total solvent retention.

A comparison of the gradients shown in Figs. 1 and 2 indicates that considerable movement of solution from the interior toward the surface occurred during the first 12 months following treatment. However, after the first 30 days, very little change occurred in the pentachlorophenol content of the interior zones. In fact, the gradients given for charges 240 and 241 in Fig. 1 suggest that most of the movement during the first 30 days probably occurs during the first 12 hours after the wood is removed from the cylinder.

The foregoing charges were end-matched and treated under identical conditions. One charge (241) was analyzed *immediately,* 30 days, and 12 months after treatment and the other (240) *12 hours,* 30 days, and 12 months after treatment. The charge initially analyzed 12 hours after treatment indicated very little movement of solution toward the surface during the next 30 days, but the charge analyzed immediately after treatment indicated extensive movement of preservative solution from the interior toward the surface during a similar period after treatment.

The fact that most solution movement has been found to occur soon after the wood is removed from the cylinder is support for the statement that this movement is caused primarily by air trapped in the interior of well-seasoned wood during an empty-cell treatment and, therefore, is described more accurately by the term "delayed kickback" rather than "migration".

The average pentachlorophenol retention given for each of the Douglas-fir and southern pine charges at each analysis as given near the top of Figs. 1 and 2 indicates that every charge lost some preservative during the first 12 months except the southern pine charge treated with the Aromatic HB solution (charge 245). Table 9 contains a summary of the net preservative loss for the charges included in the above figures. It is apparent from the data in Table 9 that considerable variation exists and that no definite pattern appears to be present, except that with pine the less volatile the solvent, the less pentachlorophenol is lost. The loss shown during the first 30 days for the Douglas-fir charges treated with the Aromatic HB and 105E solutions may be attributed to bleeding since all of these charges indicated some bleeding during this period. No active bleeding, however, was observed on these charges after the first 30 days. It is possible that the exudation of preservative was so slow as to be unnoticed.

Although both fir and pine were treated with Aromatic HB as the solvent, the losses were greater, by far, on the fir. Since the oil would not be expected to evaporate more rapidly from fir than pine, it is likely that bleeding is the cause of loss of pentachlorophenol in fir after the 30 day period as well.

The charge of fir treated with 105E as the solvent shows about the same loss

Table 5.—RESIDUAL PENTACHLOROPHENOL FOUND IN WOOD CHIPS AFTER EXTRACTION WITH TOLUENE OR TOLUENE-METHANOL FOLLOWING AN EXPOSURE PERIOD OF 12 MONTHS AFTER TREATMENT

Charge No. (1)	Species (2)	Number of Boards (3)	Treating Solution (4)	Type of Impregnating Schedule (5)	Extraction Agent or Agents (6)	Residual Pentachlorophenol in Extracted Wood Chips (lbs./cu. ft.)				Residual Pentachlorophenol in Extracted Wood Chips Expressed as Per cent of Total Present Before Extraction†			
						Outer ¼-Inch (7)	Second ¼-Inch (8)	Core (9)	Weighted Average Cross Section (10)	Outer ¼-Inch (11)	Second ¼-Inch (12)	Core (13)	Weighted Average Cross Section (14)
245	So. Pine	5	Aromatic HB-Pentachlorophenol	E-C‡ Final Steam	Toluene	0.079	0.083	0.075	0.080	8.82	20.34	23.96	16.30
246	So. Pine	5	105E-Pentachlorophenol	E-C‡ Final Steam	Toluene	0.119	0.108	0.115	0.115	19.35	38.03	46.56	32.13
256	So. Pine	5	Xylol-Pentachlorophenol	E-C, No Final Steam	Toluene-Methanol	0.002	0.000	0.000	0.001	3.80	0.00	0.00	1.62
240	Douglas-fir	4	Aromatic HB-Pentachlorophenol	E-C, Final Steam	Toluene	0.074	0.048	0.042	0.057	17.79	28.40	33.60	25.20
240	Douglas-fir	5	Aromatic HB-Pentachlorophenol	E-C, Final Steam	Toluene	0.051	0.040	0.032	0.043	11.81	23.37	37.65	23.66
247	Douglas-fir	5	105E-Pentachlorophenol	E-C, Final Steam	Toluene	0.085	0.057	0.056	0.069	19.77	36.31	37.84	29.69
252	Douglas-fir	4	Xylol-Pentachlorophenol	E-C, No Final Steam	Toluene-Methanol	0.002	0.000	0.000	0.001	5.85	0.00	0.00	2.48

*Determined by analyzing a 4.00-gram sample of the extracted and oven-dried chips.
†Based on total amount of pentachlorophenol present before extraction as given in Tables 3 and 4.
‡E-C = Empty-Cell Treatment.

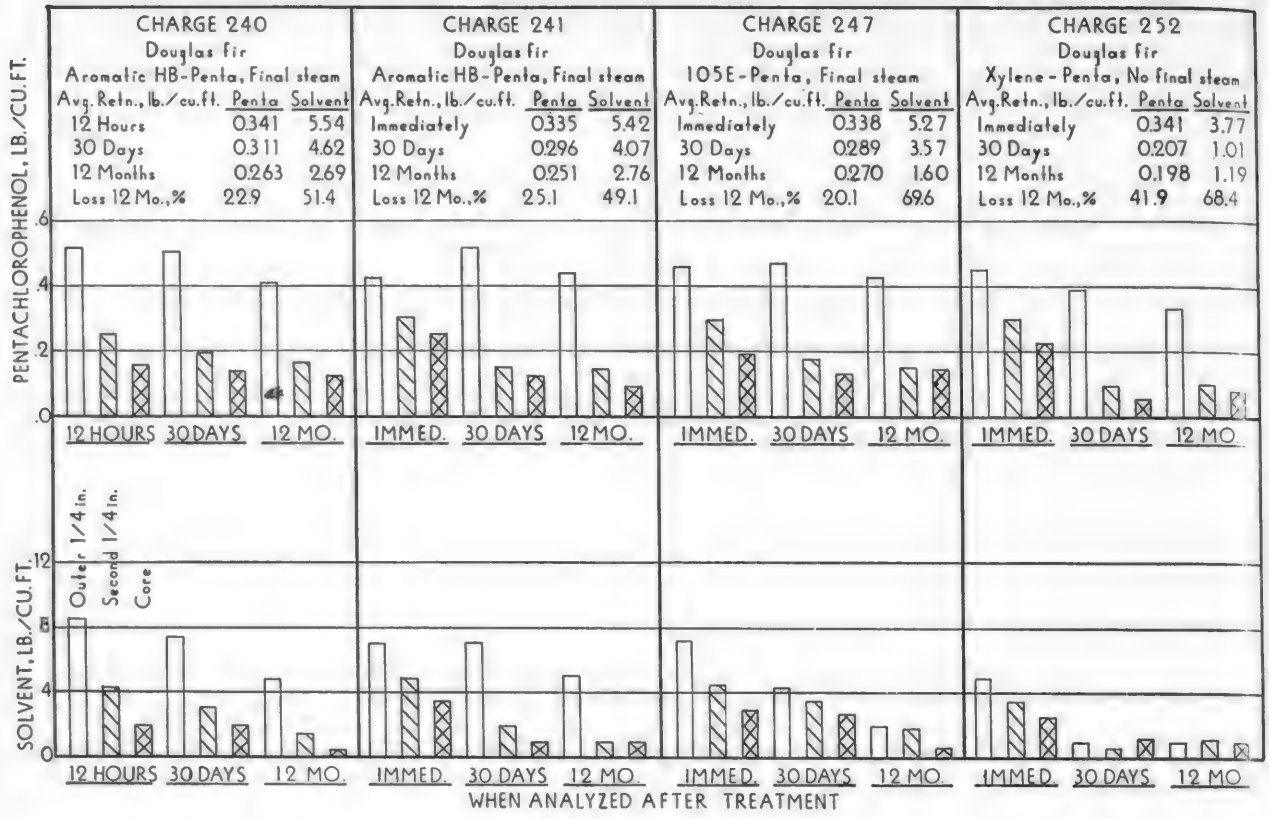

Fig. 1.—Distribution of pentachlorophenol and solvent in Douglas-fir 2- by 4-inch boards immediately after pressure treatment and after exposure periods of 12 hours, 30 days and 12 months.

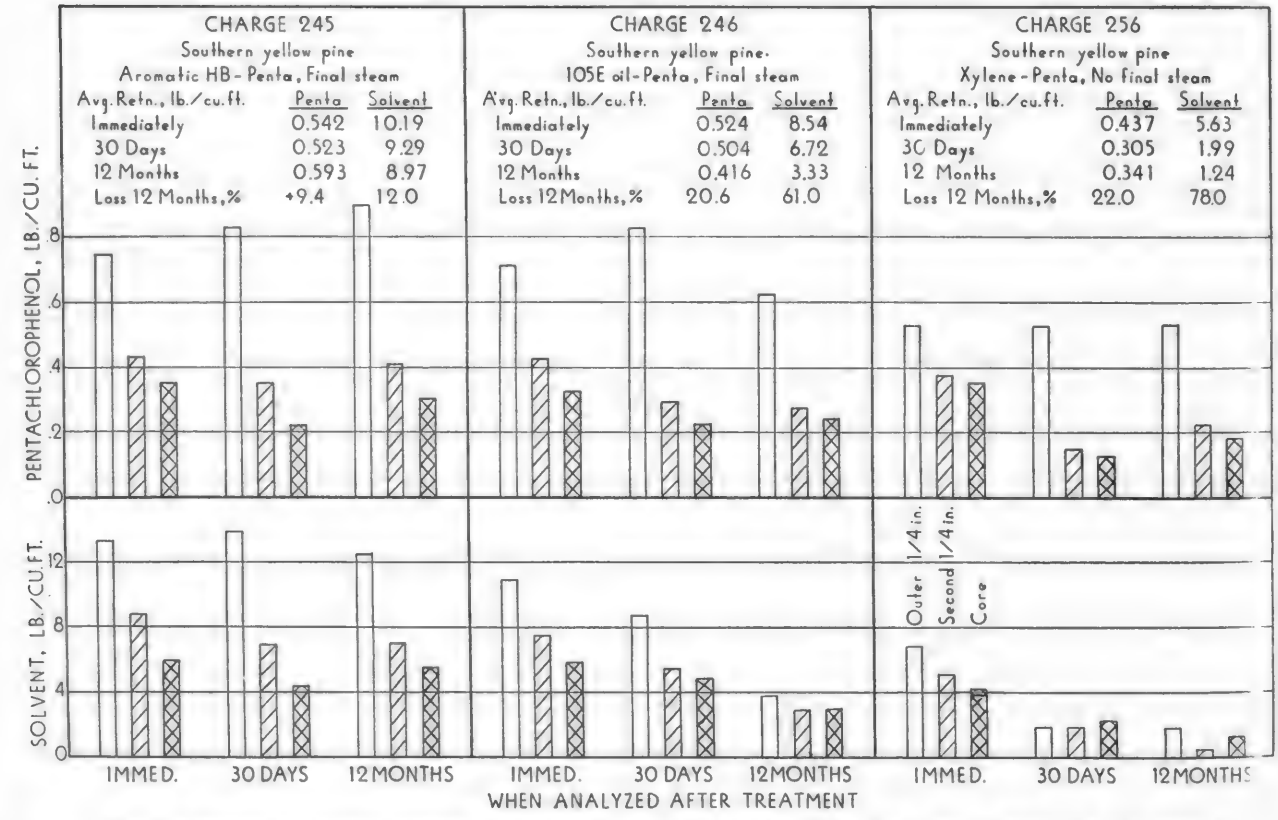

Fig. 2.—Distribution of pentachlorophenol and solvent in southern yellow pine 2- by 4-inch boards immediately after pressure treatment and exposure periods of 30 days and 12 months.

Table 8.—DISTRIBUTION OF PENTACHLOROPHENOL AND SOLVENT IN SOUTHERN PINE POLES IMMEDIATELY AFTER PRESSURE TREATMENT WITH A PENTA-PETROLEUM SOLUTION AND AFTER EXPOSURE PERIODS OF 6 AND 18 MONTHS IN A TEST PLOT*

Charge No. (1)	Pole No. (2)	When Analyzed After Treatment (3)	Distribution of Pentachlorophenol in Cross-Section† (lbs./cu. ft.) Outer ½-inch (4)	Second ½-inch (5)	Second 1-inch (6)	Third 1-inch (7)	Weighted Average Cross Section (8)	Distribution of Solvent in Cross-Section† (lbs./cu. ft.) Outer ½-inch (9)	Second ½-inch (10)	Second 1-inch (11)	Third 1-inch (12)	Weighted Average Cross Section (13)
250	1	Immediately	0.764	0.624	0.547	0.315	0.582	17.54	13.58	12.92	7.02	13.29
250	1	6 Months	0.770	0.580	0.580	0.290	0.562	10.82	10.62	12.58	13.63	11.85
250	1	18 Months	0.715	0.556	0.570	0.483	0.531	5.48	8.90	12.46	9.96	10.15
250	2	Immediately	0.814	0.512	0.223	0.083	0.425	17.47	11.31	5.69	1.91	9.51
250	2	6 Months	0.823	0.440	0.354	0.177	0.471	12.13	7.65	7.80	5.21	8.50
250	2	18 Months	0.753	0.449	0.330	0.193	0.449	8.42	7.48	7.44	4.49	7.32
251	1	Immediately	0.412	0.202	0.180	0.079	0.230	8.06	4.39	5.44	8.55	6.42
251	1	6 Months	0.378	0.260	0.212	0.112	0.252	4.94	5.12	5.51	3.85	4.99
251	1	18 Months	0.363	0.253	0.227	0.134	0.255	2.26	2.99	4.21	2.81	3.17
251	2	Immediately	0.395	0.278	0.210	0.129	0.267	10.78	6.45	5.40	7.83	7.52
251	2	6 Months	0.445	0.251	0.220	0.205	0.288	4.75	3.71	4.90	3.53	4.37
251	2	18 Months	0.448	0.310	0.247	0.232	0.319	2.30	2.32	3.02	3.11	2.66
Average		Immediately	0.596	0.404	0.290	0.152	0.376	13.46	8.93	7.36	6.33	9.19
		6 Months	0.604	0.363	0.342	0.196	0.393	8.16	6.78	7.70	6.56	7.43
		18 Months	0.570	0.394	0.344	0.261	0.404	5.37	5.42	6.86	5.09	5.83

*Impregnating solution consisted of 4.90% pentachlorophenol in Aromatic HB Oil.
†Pentachlorophenol and solvent retentions based on density (oven-dry weight and green volume) of extracted chips from sections analyzed 6 months after treatment.

in the first 30 days as in the next 11 months, which could mean the bleeding rate here was also slow. Blooming could be a factor with the charges treated with 105E-pentachlorophenol since it is fairly volatile and only 30 to 40 per cent of the original solvent was still present after 12 months. It is also possible that evaporation, in part, could cause some pentachlorophenol to be drawn to the surface with this volatile oil.

The losses shown for the charges treated with the xylol-pentachlorophenol solution, of course, are related primarily to blooming, although some bleeding occurred on these charges soon after treatment.

Weathering may have contributed to the reduction but it does not seem likely that it would bring about a 16 to 18 per cent drop in the outer ¼-inch in 11 months. The pine charge treated with 105E-pentachlorophenol also indicates a reduction in the outer ¼-inch. However, the pine charges treated with the Aromatic HB-pentachlorophenol and xylol-pentachlorophenol solutions indicate more pentachlorophenol throughout the cross-section after 12 months' exposure than was present 30 days after treatment. The later is not unusual when one considers that the retention throughout a given board is not uniform and that different sections from the same board will probably indicate slightly different retentions.

As mentioned previously, treatments with coal tar creosote also were included with the previous tests for comparative purposes. Data for the charges treated with creosote are given in Table 10. The data in the latter table are presented in graphical form in Fig. 3. The data for southern pine offer a means of comparing the effect of final steaming on the creosote gradient in 2- by 4-inch boards. Both of the Douglas-fir charges, however, were steamed after treatment and no similar comparison is possible for this species.

Boards of each species were end-matched. The pine charges were analyzed immediately, 24 hours, and 36 days after treatment. Bleeding was evident on all of these charges shortly after treatment except the pine charge given a final steaming (charge 290). In spite of the absence of bleeding on the latter charge it will be noted that 11.9 per cent of the original creosote retention was lost during the first 36 days after treatment as a result of evaporation from the outer ¼-inch.

In contrast, the pine charge which was not steamed after treatment (charge 289) lost 26.9 per cent of its original retention during the first 36 days after treatment. The loss for this charge was caused primarily by bleeding. With the latter charge, the loss was uniform throughout the cross-section, and this seems to indicate that trapped air also causes movement of creosote from the center to the surface of wood pressure treated with this preservative.

Pentachlorophenol Gradients in Southern Pine Poles: The distribution of pentachlorophenol and solvent in four southern pine poles immediately, 6 months, and 18 months after treatment and exposure is shown in Table 8. The poles represented were

Table 9.—SUMMARY OF PENTACHLOROPHENOL LOSSES FROM DOUGLAS-FIR AND SOUTHERN PINE 2- BY 4-INCH BOARDS DURING FIRST 12 MONTHS AFTER TREATMENT

Charge No.	Treating Solution	Per cent of Original Pentachlorophenol Lost at End of First 30 Days and 12 Months After Treatment: Southern Pine 30 Days	Southern Pine 12 Months	Douglas-fir 30 Days	Douglas-fir 12 Months
240	Aromatic HB-Pentachlorophenol*	----	----	8.8	22.9
241	Aromatic HB-Pentachlorophenol*	----	----	11.6	25.1
245	Aromatic HB-Pentachlorphenol*	3.5	+9.4	----	----
247	105E-Pentachlorophenol*	----	----	14.5	20.1
246	105E-Pentachlorophenol*	3.8	20.6	----	----
252	Xylol-Pentachlorophenol	----	----	39.3	41.9
256	Xylol-Pentachlorophenol	30.2	22.0	----	----

*All charges treated with these solutions were given a final steam bath.

Table 10.—DISTRIBUTION OF COAL TAR CREOSOTE IN 2- BY 4-INCH BOARDS IMMEDIATELY AFTER PRESSURE TREATMENT AND AFTER EXPOSURE ON A TEST FENCE FOR 36 DAYS

Charge No. (1)	Number of Boards (2)	Species (3)	Type of Impregnating Schedule (4)	When Analyzed After Treatment (5)	Distribution of Creosote in Cross Section (lbs./cu. ft.) Outer ¼-inch (6)	Second ¼-inch (7)	Core (8)	Weighted Average Cross Section (9)
287	5	Douglas-fir	E-C* Final Steam	Immediately	9.09	4.17	1.58	5.61
287	5	Douglas-fir	E-C* Final Steam	36 Days	7.13	3.42	1.33	4.47
288	5	Douglas-fir	E-C, Final Steam	24 Hours	9.13	4.34	2.17	5.82
288	5	Douglas-fir	E-C, Final Steam	36 Days	7.34	3.68	1.91	4.79
289	5	So. Pine	E-C, No Final Steam	Immediately	16.31	9.68	8.29	12.16
289	5	So. Pine	E-C, No Final Steam	36 Days	12.91	6.29	5.38	8.89
290	5	So. Pine	E-C, Final Steam	Immediately	14.38	9.04	7.77	11.01
290	5	So. Pine	E-C, Final Steam	36 Days	11.08	9.58	7.46	9.70

*E-C = Empty-cell treatment.

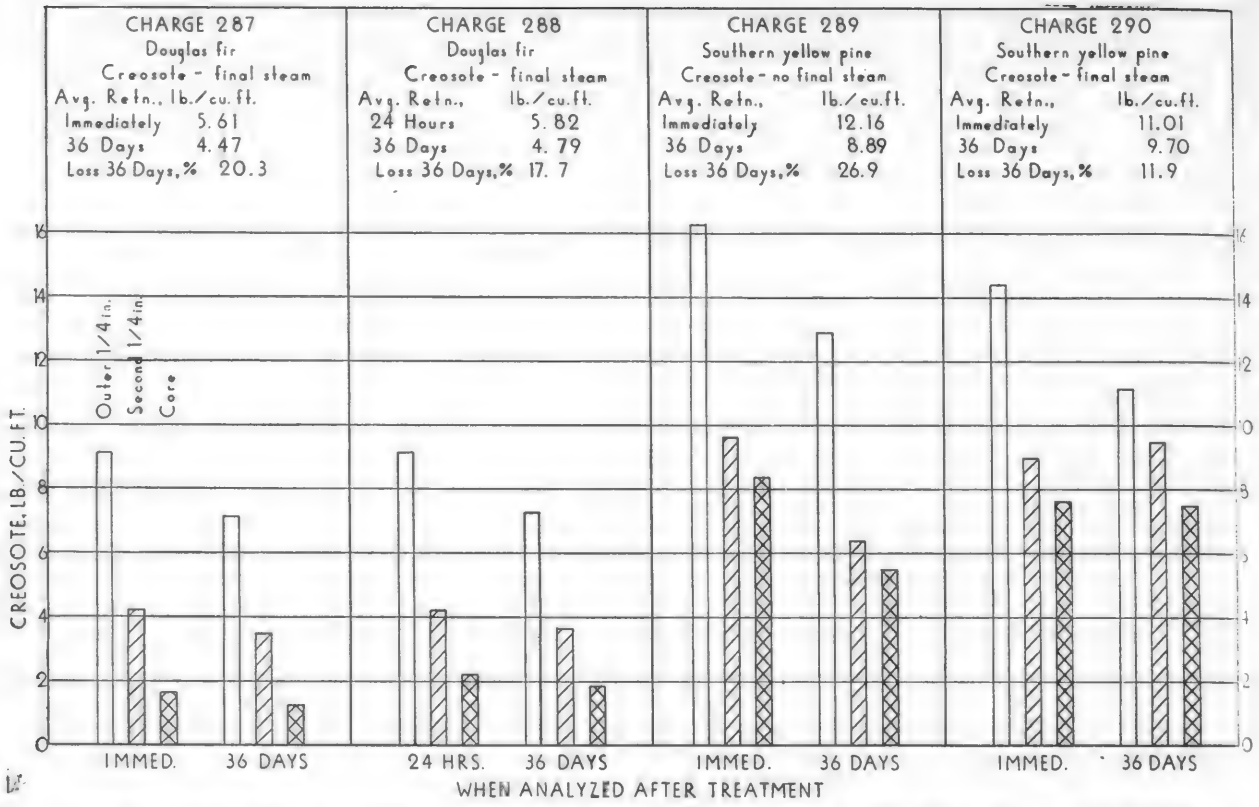

Fig. 3.—Distribution of coal tar creosote in Douglas-fir and southern yellow pine 2- by 4-inch boards immediately after pressure treatment and after exposure for 36 days.

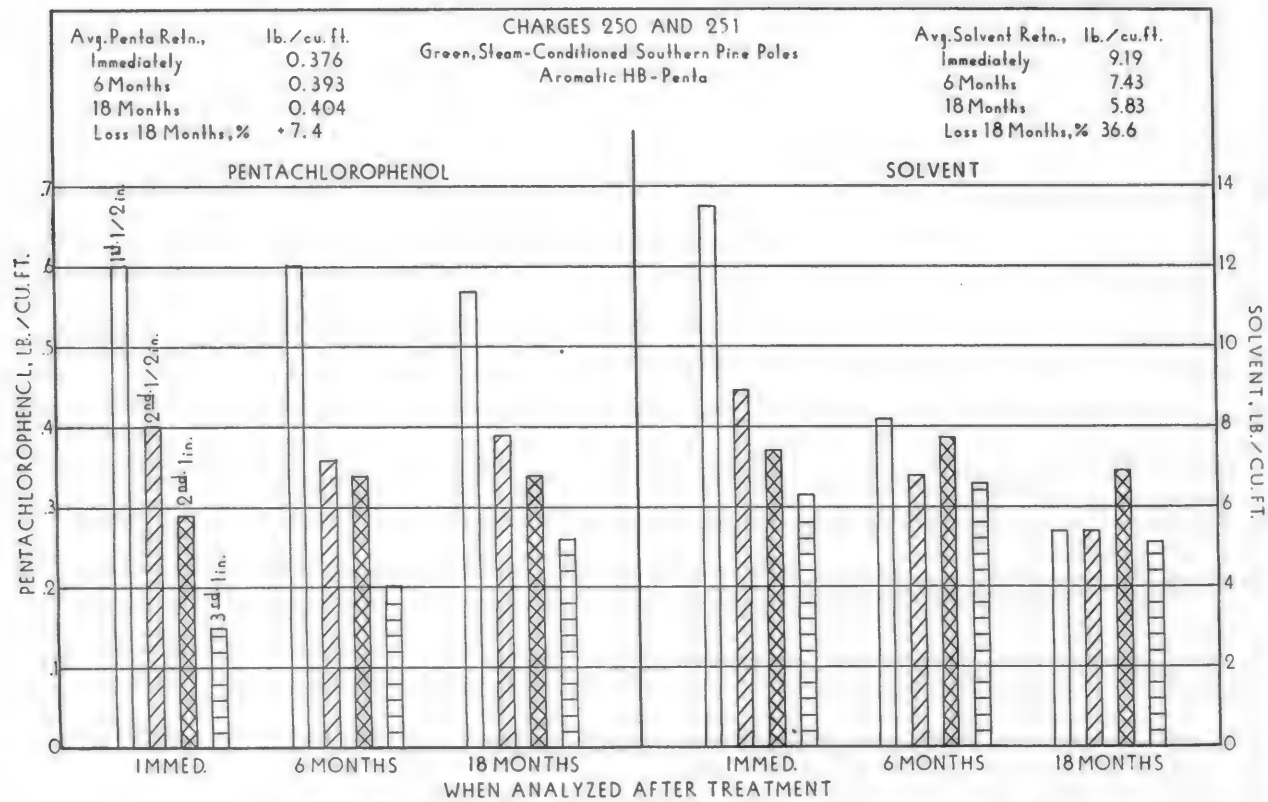

Fig. 4.—Distribution of pentachlorophenol and solvent in green, steam-conditioned southern yellow pine poles immediately after pressure treatment and after exposure for 6 to 18 months.

green and were steam-conditioned before treatment. No bleeding was observed on the poles during the exposure period. The data in Table 8 are presented graphically in Fig. 4. An examination of the data in this figure indicates that no appreciable movement of pentachlorophenol occurred during the first 18 months after treatment, although a large part of the solvent evaporated from the outer 1-inch of the poles during this period. For instance, 39 per cent less solvent was found in the second ½-inch 18 months after treatment than was present in this same zone immediately after treatment. The average pentachlorophenol retention in this zone, however, was unchanged 18 months after treatment.

Since the pentachlorophenol retention remained the same while the solvent retention decreased, it appears that the solvent moved in the vapor phase to the surface. Since pentachlorophenol remains in the solid state, it remains in essentially the same place where it was deposited by the original impregnation.

Summary

A small to moderate loss of preservative may be expected from Douglas-fir lumber and dimension stock pressure treated by the empty-cell process with pentachlorophenol in a wide range of solvents or with coal tar creosote. With the usual aromatic gas oil solvent used with pentachlorophenol, the loss from wood is mainly caused by exudation of preservative shortly after treatment. A final steaming of the treated wood will reduce this exudation. The net loss during the first 12 months after treatment was found to be a maximum of 25 per cent. Treatments with lower distillation range solvents will result in equal or greater losses due to exudation and some blooming after a substantial portion of the solvent has evaporated.

No loss of pentachlorophenol or exudation of preservative was found with southern yellow pine 2-in. by 4-in. by 8-ft. boards, pressure treated, using an aromatic gas oil as solvent, in the first 12 months after treatment. However, using an aromatic kerosene there was a considerable loss of pentachlorophenol. This may have been caused by more rapid evaporation of the solvent, with resultant deposition of pentachlorophenol on the wood surface.

There was no evidence of pentachlorophenol loss from southern yellow pine poles which had been treated in the unseasoned state with pentachlorophenol in an aromatic gas oil. This was over an 18-month period. In the same poles, however, there was a substantial loss of solvent as far inward as the second inch during the same exposure period. This may indicate, under these conditions, that the solvent moved to the surface of the wood as a vapor rather than a liquid. With this state of affairs the pentachlorophenol would be left behind.

Conclusions

1. Kiln-dried wood treated by the empty-cell process with pentachlorophenol in a petroleum solvent or with coal tar creosote loses preservative shortly after treating due mainly to trapped air forcing out the solution.

2. A final steaming of the treated lumber normally reduces this loss or exudation.

3. There is increasing loss of preservative in dry southern yellow pine sapwood, treated by the empty-cell process, as the volatility of the solvent for pentachlorophenol increases.

4. Little or no loss of pentachlorophenol will occur from unseasoned southern yellow pine poles in 18 months that have been empty-cell treated using a medium distillation range aromatic gas oil as the solvent.

Discussion

A. W. Stout (Western Pine Assoc.): How was the amount of residual creosote in wood after toluene extraction determined?

Mr. Behr: By the method proposed by Roy M. Baechler, U. S. Forest Products Lab, in Proc. A.W.P.A. 50 (1954).

C. C. Walden (B. C. Research Council): This method leaves about 2 per cent creosote in the wood, but about 2 per cent of the wood is soluble in toluene, so it balances out nicely.

Paper-Overlaid Veneer Applications[1]

JOSEPH P. FOLEY

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Specific applications of paper-overlaid veneers in the packaging and industrial fields are discussed. As packaging material, paper-overlaid veneers are available in standard and cut-to-size panels, and in cleated and non-cleated containers. These materials may be die cut, bent, shaped, riveted, sewed, and machined. As a result, they are in demand as components of manufactured products for industrial and consumer use.

MANY NEW APPLICATIONS for paper-overlaid veneers have developed during the past few years. These products consist of a single sheet of veneer overlaid on each face with paperboard. The veneer cores are either softwood or hardwood species and vary in thickness from 1/16″ to 3/16″. Fourdrinier or cylinder kraft paper of weight ranging from 26 lb. to 90 lb. per thousand square feet is generally used for the paper overlay. Present production consists mostly of kraft overlays. One large manufacturer produces overlays of different colored paper. Aluminum foil and printed overlays are in the experimental stage and may be produced in larger quantities in the future.

Production of paper-overlaid veneers has substantially increased in 1954 and 1955. Principal producers are Weyerhaeuser Timber Company, Springfield, Ore.; Chicago Mill and Lumber Co., Tallulah, La.; U. S. Plywood Corp., Laconia, N. H.; and American Box Corp., San Francisco. The Weyerhaeuser product is marketed under the trade name of Ply-Veneer, the Chicago Mill and Lumber Company product as Craveneer, and the U. S. Plywood Corp. product as Tekwood. In addition, a number of other manufacturers operate under license from Chicago Mill and Lumber Company and produce paper-overlaid veneer under the trade name of Craveneer. Fruit Growers Supply Co., Westwood, Calif.; California Barrel Co., San Francisco; Interstate Container Corp., Red Bluff, Calif.; and Elberta

[1] Presented at Session V, Packaging, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

The Author: Joseph P. Foley was engaged in the retail building material field in New England from 1930-37. He was associated with Wood Conversion Co., St. Paul, Minn., from 1938-42 and 1945-47. During World War II, Foley served in the U. S. Air Force as an aircraft engineering officer.

Fig. 1.—Paper-overlaid veneer boxes being assembled at aircraft plant.

Crate and Box Co., Bainbridge, Ga., are Craveneer licensees.

Construction Types

Standard Panels: The most commonly used standard panel is 4 by 8 ft. Manufacturers using the continuous process can readily produce longer lengths, with 12 feet generally the longest length commercially available. Inquiries for 20 ft. lengths and longer have been received, but inability to efficiently handle, load, and ship has limited the sale of extremely long panel lengths.

Liners: Sometimes referred to as collars or sleeves, liners are available in almost any width and length. They are commonly used as inserts for fiberboard containers. Paper-overlaid veneer liners substantially increase stacking strength, particularly where long storage periods and high humidities prevail. Most liners are usually furnished in one piece, with corner scoring, enabling the sleeve-like collar to be easily folded and inserted inside the fiberboard container.

Cut-to-Size Panels: Some users prefer to purchase panels cut to their exact size requirements. This bypasses cutting at container assembly point, permitting immediate cleat attachment by the box maker. Slats for fruit and produce boxes can be classified as cut-to-size material.

Cleated and Cleatless Containers: Cleated boxes are available in a number of types. Cleats may be of any dimension and can be fastened to the box shell or to the box end. The assembly is shipped flat to point of use, where it is easily and economically assembled. In most instances these containers can be re-used a number of times. Cleatless containers are routed and slotted blanks of paper-overlaid veneer that can be fastened with staples.

Military Uses

The military services utilize containers made from paper-overlaid veneer for both domestic and overseas shipments. Many U. S. Air Force installations find lightweight, low-cost paper-overlaid veneer boxes ideal for air cargo as well as rail and truck shipments. Use of these containers complements the successful tare weight reduction program of the U. S. Navy. Packaging specialists of various U. S. Army branches have expressed keen interest in the possibilities of the paper-overlaid veneer container..

The federal specification for paper-overlaid veneer is interim Federal Specification PPP–V–00205b (USAF). The applicable container specification is MIL–B–10377A. Packaging sections of the Air Force and Navy, and the Quartermaster Corps of the Army, are presently processing the coordination of these two specifications. MIL–B–10377A will ultimately become a federal specification. When accomplished, the number of types and styles of containers utilizing paper-overlaid veneer for the military as well as its contractors should be substantially increased.

Many manufacturers producing material for the various branches of the military package these products in paper-overlaid veneer containers in accordance with existing federal and military specifications. The aircraft industry utilizes many millions of square feet annually in this manner. Low cost and light weight combined with excellent stiffness qualities and puncture resistance make paper-overlaid veneer particularly adaptable for the unique packaging requirements of this industry. Many military installations find it advantageous to purchase paper-overlaid veneer in large size panels. The most commonly used size is 4 by 8 ft. It is also available in 6 to 12 foot lengths from some manufacturers. Smaller sizes are cut from the larger panels according to requirements.

One aircraft manufacturer has pioneered the "Modular Box" which handles a variety of package sizes with a minimum of panel sizes. This firm has developed a system whereby 36 prefabricated panels of various combinations are used to assemble 113 different master containers with displacements ranging from 4.6 to 26.3 cu. ft. The 36 basic panel sizes are cut from larger panels. By placing the material to be packed on a table marked off in two inch squares, the shipping clerk can determine at a quick glance the size box that is required. Other aircraft manufacturers have adopted similar systems and report substantial reduction of packaging costs.

Military packaging specifications specify minimum thicknesses of paper-overlaid veneer panel board from which the box is manufactured. These categories range from boxes with contents under 70 lbs. to those with loads as high as 500 lbs. and minimum thicknesses increase proportionately. Minimum sizes of edge cleats also increase with the weight of the package.

Fig. 2.—Packaging crew selects correct size of modular box at aircraft plant.

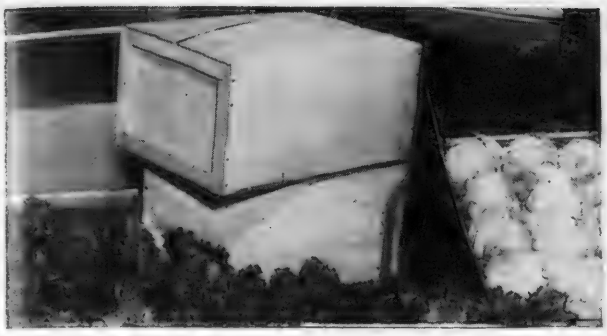

Fig. 3.—Paper-overlaid veneer lettuce box.

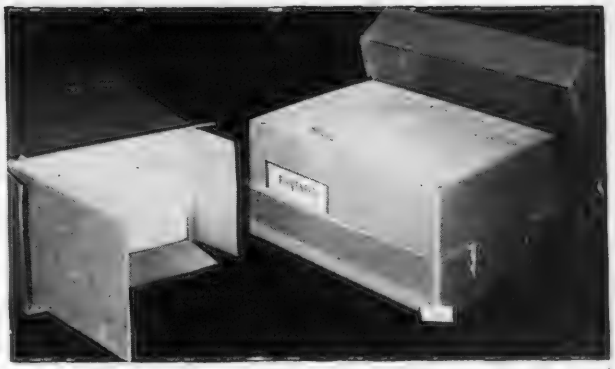

Fig. 4.—Cheese packages, with paper-overlaid veneer liner inserted into fiberboard box.

Many industries have developed a number of uses for paper-overlaid veneer containers and container parts. Some of these are: containers for carpets and rugs, office equipment, explosives and acids, glass and mirrors, stainless steel and aluminum sheets, oxygen tanks, circular saw blades, nuts and bolts, air conditioning units, television tubes, automobile parts, refrigerators, freezers, water heaters, washing machines, stoves, sewing machine cabinets, porcelain enamel sinks and wall cabinets, caskets, doors, and paper products.

The furniture warehouse industry has developed new types of moving storage vaults with paper-overlaid veneer. As the items are removed from the customer's home, they are packed in a specially designed vault which is closed, banded with steel strapping, and sealed with a numbered seal in the owner's presence. The vaults are transported to and from the warehouse on a flat bed trailer which is only 16 inches high. They remain on the trailer while being loaded, and all handling of vaults is with fork lift.

Paper-overlaid veneer pallets combine low cost with light weight. This combination is a must in the "expendable" pallet field. One western equipment handling firm has developed a non-returnable pallet from paper-overlaid veneer that meets the requirements for a low cost, non-returnable lightweight pallet that is easily assembled and stored. A minimum consumption of cubic space is achieved by shipping the various components "knocked down" and assembling at the initial shipping point. Many firms with volume pallet requirements are testing this unique pallet, and the manufacturer anticipates an increasing demand for it during the next few years.

Paper-overlaid veneers are used as protective boxcar liners and separators by a number of firms. Chemical manufacturers use large panels for separation and protection during shipment of high value products. These panels have been used as spacers for stainless steel kegs on beer shipments. One manufacturer of an expensive tubing places panels of paper-overlaid veneer between tubing ends to prevent damage in transit.

It has been forecast that the fruit and produce industries offer the greatest volume potential for paper-overlaid veneer containers. It appears that only a small portion of the actual potential has been developed, although substantial quantities of these shipping containers are being utilized in the fruit and produce field at this time.

One manufacturer of paper-overlaid veneer has confined its marketing and production activities to packages for shipping perishable produce. Emphasis has been on perfecting a lettuce crate. It is reported that the paper-overlaid veneer lettuce crate is in widespread usage in the winter lettuce producing area, which includes the Imperial valley of California and the Salt River valley of Arizona.

The primary reason for the initial success of this crate is that it is adaptable to all types of refrigeration. Up until a few years ago, all lettuce was shipped in wooden crates. When transcontinental shipment was involved, about 20,000 lbs. of snow ice were blown in on top of the load, plus the ice that was packed in each crate of lettuce. The fiberboard lettuce carton was developed within the last few years. This carton has its limitations when in direct contact with moisture, and the only way it can be refrigerated is by vacuum cooling at the point of origin and shipped in a standard refrigeration car, which has ice only in the bunkers.

The paper-overlaid veneer lettuce crate can be used with ice in the package, with ice blown in on top of the load in a refrigerator car, or can be vacuum cooled. It is reported that this lettuce container sells at a price substantially below the cost of wooden crates and slightly higher than the price of corrugated cartons, but the ability to be shipped under all types of refrigeration appears to offset that penalty. Development work continues with paper-overlaid veneer containers for celery, broccoli, pears, apples, and other fruit and produce products. Sales are not significant enough at this time to forecast future volume of these particular containers.

Another large producer of paper-overlaid veneer furnishes liners or collars for fiberboard citrus shipping containers. This company reports that the kraft paper covered veneer collar strengthens these cartons in storage. Another type of package is a citrus shipping container with tops, bottoms, and sides consisting of kraft paper covered veneer slats combined with conventional wooden box ends. Another type is a wrap-around shell of paper-overlaid veneer, nailed to wood ends. The collar and wrap-around shell approach has also been used for shipping apples in the state of Washington and in a few areas in the eastern United States. Sales of these types of apple shipping containers have not been of consequence to date.

Paper-overlaid veneer cleated containers are used to pack and ship bulbs to all sections of the United States. One large shipper of bulbs in Oregon reports that the combination of a lightweight, low-cost container that carries attractive printing produces one of the outstanding packages in this field. In the East, a shipper of roses has found a scored paper-overlaid veneer wrap-around shell with wooden ends an ideal package to meet his requirements. Attractive printing in desired color combinations is another plus value for paper-overlaid veneer panels and containers, as most manufacturers have printing equipment available.

The cheese industry has been a large consumer of paper-overlaid veneer, with the principal use being for liners or collars in fiberboard containers. Forming and stacking strength is acquired by the combination of a paper-overlaid veneer liner and a low test carton. The cheese, in 40, 60, and 80 lb. units or blocks, can be cooled, processed and stored for as long a period as necessary. The insertion of a folding paper-overlaid veneer liner

allows stacking of the cheese containers to heights that economical storage demands. It also prevents bulging and subsequent waste when the cheese is processed into smaller packages for resale to the consumer. This package combination has recently been approved for domestic shipments by the U. S. Dept. of Agriculture.

In certain areas, these liners may be re-used and it is estimated that as many as 4 or 5 trips may be completed before the liner has to be discarded. The following table demonstrates the increased stacking strength properties in a typical fiberboard carton in combination with paper-overlaid veneer liners:

COMPRESSION TESTS

Box No.	Liner	Comp. at Max. Load in.	Max. Load lb.
195 (control)	No liner	0.52	560
195b (control)	No liner	0.50	740
Ave. of Controls	No liner	0.01	650
	Paper-Overlaid Veneer		
197	1/8" 42-42*	0.75	6000
206	1/8" 42-42*	0.81	4660
205	1/8" 42-42*	0.88	4500
Ave.	1/8" 42-42*	0.81	5053
	Paper-Overlaid Veneer		
196	3/16" 42-42*	0.76	7920

*Designates weight of paperboard on each side of liner.

A number of transcontinental carload shipments of frozen fish have been made in specially designed paper-overlaid veneer cleated and cleatless containers. The product arrives in excellent condition at a lower cost because of lower container costs and reduced container weight. Utility of paper-overlaid veneer containers for meat and poultry has been limited to date.

Paper-overlaid veneer has a number of uses other than packaging. Some examples of these are: divan and drawer bottoms; hassock, wardrobe, cabinet, and other furniture components; mirror backs, templates, bin separators, auto and trailer interiors parts, cigar boxes, grain doors, toy chests, and fireproof door cores. Paper-overlaid veneer is being widely used in the luggage field. It is used as a component part of suitcases, trunks, footlockers, and other luggage items. Displays, indoor games, toys, signs, and scenic backgrounds can be effectively and economically created from this product.

Paper-overlaid veneer has some utility in the construction industry. Markets are still somewhat limited and some no doubt will have to be proven in actual use. Utility as temporary partitions, summer cottage partitions, garage, closet, basement, attic, and granary lining, construction barricades, and concrete form liners will ultimately be determined by product performance in the field.

The number of uses for paper-overlaid veneer in the experimental and testing stage probably exceeds the number of commercialized uses. This product is still relatively new and it can be expected that the number of new uses for it as a packaging material in the next two or three years may exceed proven known uses at this time.

The U. S. Forest Products Laboratory, Madison, Wis., in cooperation with the U. S. Air Force, has undertaken a project which will determine capabilities and limitations of cleated paper-overlaid veneer containers, as compared to cleated fiberboard and cleated wooden boxes. Results, when available, should be valuable to all segments of industry and to the military services.

Costs vary in different areas depending on location of the paper-overlaid veneer manufacturing plants and freight involved. Costs of finished containers and container parts vary with size and type. In most areas, 1/10" and 1/8" paper-overlaid veneers are competitive with comparable thicknesses of container grade plywoods. As thickness increases, paper-overlaid veneer prices generally show to greater advantage, particularly when compared with plywood of higher grades. Paper-overlaid veneer now being developed for overseas shipments for the military should have substantial price advantages over comparable thicknesses of weather resistant plywoods.

From the manufacturing viewpoint, the production of paper-overlaid veneer results in better utilization of available raw materials. As the veneer core is covered with strong and durable kraft paper, high grade veneers are not required.

Paper-overlaid veneer production can help to establish a balance in the plywood plant. Many logs having a small but high quality veneer content are not always peeled. These logs are now being peeled by manufacturers of paper-overlaid veneer, with the shell of excellent clear A grade veneer going into plywood face stock, and the bulk of the log being used in paper-overlaid veneer.

Some manufacturers report certain objectionable knots and crossgrain creep into boxes which would normally be rejected. When this same of objectionable veneer is combined and covered with paper and glue, the defects are gone and a new strength is acquired. Container board is an integral part of paper-overlaid veneers. The inside part of a low grade log which would not be economically used for either plywood veneer or paper-overlaid veneer can be converted to kraft board in the pulp mill and used in the outer facings of paper-overlaid veneer.

Most producers of container raw materials would like to feel that his is the ideal product for every type of container. However, in most cases it has been necessary to concentrate on selective markets where economics and package performance are attractive to the prospect. The wooden box and paper-overlaid veneer box makers are well aware that they cannot compete with the fiberboard manufacturers on packages for domestic shipment of canned vegetables. The fiberboard manufacturers are equally aware that it would be difficult to package a heavy and valuable aircraft engine with fiberboard. Uses listed earlier in this report are results of seeking selective markets where the paper-overlaid veneer container performance in relation to its cost justifies its selection.

Numerous opportunities exist for container combinations of wood, fiberboard, and paper-overlaid veneer. The fiberboard cheese container with the paper-overlaid veneer liner, citrus boxes of wood ends and paper-overlaid veneer slats, and the wrap-around paper-overlaid veneer shell combined with a typical wood box end are examples of combinations of wood, fiberboard, and paper-overlaid veneer that offer new opportunities for package design to the military, to the farmer, and to industry.

Discussion

C. B. Moore (Western Growers Assoc.): Please enlarge a little on the water resistance of overlaid veneer board.

Mr. Foley: Most paper-overlaid veneers have to be water resistant to withstand domestic shipping conditions. Tests for military uses by the Forest Products Laboratory are also followed for commercial uses. Most veneer panels will stand the 3–5 cycle 4-hour soak test. Each cycle consists of 4-hours soak and 20-hours drying period. Some manufacturers are using 10-cycle tests also.

A. R. Tegge (Quartermaster Container Laboratories): Do you have any production figures which indicate the increased usage of paper-overlaid veneer for container applications?

Mr. Foley: I would estimate current production to be 300–400 million surface feet (all thicknesses) compared to 100 million feet 3 to 4 years ago.

E. W. Wellwood (Canadian Forest Prod. Ltd.): Have containers made from paper-overlaid veneer been used for apple shipments?

Mr. Foley: There is some paper-overlaid veneer being used as liners for apple crates. I don't have exact production figures but some is being used in combination with other materials. It is being used for sides and bottoms of apple crates in combination with conventional slat tops and wooden ends.

Some Structural Details of Douglas-Fir Pit Membranes by Phase Contrast[1]

RALPH O. MARTS

Technologist, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

Some excellent details of the pit membranes of bordered pits were observed in a recent microscopical study of tracheid structure of Douglas-fir springwood by phase contrast. Apparent perforations in pit membranes and distortion of the tori to block the pit openings may both be important from the standpoint of pressure treatment of wood.

BORDERED PITS OF CONIFERS are of great importance, both physiologically as paths of translocation of water and solutes in the living tree and technologically as areas for movement of preservatives and other substances in timbers. The existence of perforations in the pit membranes and distortion of the torus is of particular interest to the wood-preserving industry.

I. W. Bailey (1, 2)[3] reported the membranes of the bordered pits as not always entire, and pictured perforations occurring radially in the thinner bands of membrane substance. Investigations of pit structure with the electron microscope by Liese and Hartmann-Fahnenbrock (3) support the conception of a torus kept in its middle position by radial filaments. Electron microscopic observations of sections by Frey-Wyssling and Bossard (4) show the closing membrane consisting of three lamellae, corresponding to the two primary walls of the adjacent cells and to the middle lamella. They conclude that the closing membrane of bordered pits contains no perforations and that dimensions of pores are submicroscopic. They report apparent openings closed by the primary wall, which acts as an ultrafilter. Stereoelectron microscopic investigations of bordered pits of conifers by Eicke (5) lead her to conclude that the torus is supported by radial filaments and that elongated perforations do exist.

In a recent microscopical study of tracheid structure of Douglas-fir springwood by phase contrast, some excellent details of the pit membranes of bordered pits were observed. These specimens, obtained from air-dried lumber, had been prepared for sectioning by boiling them in water under reduced pressure until they sank. They were then dehydrated in the alcohol series and embedded in nitrocellulose. Radial sections cut with a sharp microtome knife and stained with Heidenhain's hemotoxylin, or unstained, occasionally showed the overarching walls of bordered pit cavities, cut away so as to expose face views of portions of the pit membrane of the bordered pit together with the torus. At high magnifications, features of the pit membrane and the torus were observed and photographed (Fig. 1). In the center is the circular thickened portion,

[1] A contributed paper.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to literature cited.

The Author: Ralph O. Marts holds B.S. in biology from Ottawa U., Kansas, and M.S. in botany from Iowa State College. He was a research assistant at Iowa State College from 1926–29, when he joined the staff of the U. S. Forest Products Lab. Marts served as an aerial interpreter in the U. S. Army Air Corps from 1942–45.

Fig. 1.—Douglas-fir springwood tracheid with overarching walls of the bordered pit cavities cut away, exposing face views of depressed tori and portions of pit membranes forming radial patterns. Enlarged to 2,000 diameters from inset photomicrograph made at 800 diameters.

or torus, distorted and pressed partly through the pit aperture. With the torus in this position, it must effectively block these openings. Surrounding the torus are portions of the pit membrane, showing a radial network of ribbon-like strands and what appear to be radial openings, variable in size. The disruption of portions of the network has been produced by sectioning and preparation of the microscopic mount. Measurements of a bordered pit photographed are approximately as follows:

Diameter of the border, 23 microns.
Diameter of the torus, 11 microns.
Diameter of the aperture, 7 microns.

What appear to be perforations in pit membranes and distortion of the tori in such a way as to block the pit openings may both be important from the standpoint of impregnation of wood under pressure with preservatives and other substances.

Literature Cited

1. Bailey, I. W. 1913. The preservative treatment of wood, I. II. *Forestry Quarterly* 11:5.
2. Bailey, I. W. 1954. The preservative treatment of wood, II. Reprinted in *Contributions to Plant Anatomy*. Chronica Botanica Co., Waltham, Mass. 15 (1/6): 207.
3. Liese, Walter, and Hartmann–Fahnenbrock, Margarete. 1953. Elektronenmikroskopische untersuchungen ueber die hoftuepfel der nadelhoelzer. *Biochimica et Biophysica Acta* 11:190.
4. Frey–Wyssling, Albert, and Bosshard, Hans Heinrich. 1953. Ueber den feinbau schliesshaute in hoftuhfeln. *Holz als Roh- und Werkstoff* 11(11):418.
5. Eicke, Ruth. 1954. Beitrag zur frage des hoftuepfelbaues der koniferen. *Ber. Dtsch. Bot. Ges.* 67(6/7):213.

The Chem-Dry Process—A Rapid Method for Hardening Inks and Coatings[1]

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Owner, Chemical Processes, Columbus, Ohio

Describes a fast drying process applicable to finishing many types of forest products. Coated materials are passed through chamber containing sulfur dichloride and finish hardens in few seconds or minutes. Lists advantages and disadvantages of process in comparison to other drying methods.

THE CHEM-DRY PROCESS is a new and basically different method for rapidly hardening coatings of paints, varnishes, and inks. It depends on the chemical reaction between the vehicle of the coating and sulfur dichloride. This material cross-links the resins and oils so that they are quickly solidified. The action is chemically similar to drying by oxidation except that sulfur dichloride is the linking agent rather than oxygen.

The hardened coating is different chemically from one dried by air oxidation or baking. Both sulfur and chlorine from the hardening agent remain in the film although they are present in an inactive form.

The process was developed by Armour Research Foundation for The Meyercord Co., Chicago. It is being offered to industry for use on a royalty basis and several licensees are currently going into commercial operation. A pilot plant is operated at Armour to demonstrate the process to interested companies.

The Chem-Dry method has potential application wherever paints, varnishes, or inks are used, with many of the best applications on forest products. Inks, paints, varnishes, and fillers harden before they soak in with this process, thereby giving greater hiding power, coverage, and gloss. A single coat of paint on fir plywood, if hardened immediately by this method, will completely eliminate the appearance of grain. Porous kraft paper can be printed and Chem-Dried, giving better ink coverage than with standard methods. Composition boards can be finished with less paint than would otherwise be necessary.

Drying is one of the most important problems in wood finishing. If alkyd resins could be hardened rapidly, they would, in many cases, supplant the use of lacquers which dry only by solvent evaporation and which have certain disadvantages. The Chem-Dry process is a means for doing this which has interesting possibilities. Fillers, sealers, primers, enamels, and varnishes can all be formulated based on alkyd resins and other reactive vehicles. In this way, the complete finish can be hardened by the Chem-Dry process.

This should permit the first coat to be applied and then hardened sufficiently so that within a few seconds or minutes, the next coat can be applied and hardened. The process is applicable to the finishing of flat and irregular surfaces and can be used for decorating, printing, repairing and refinishing.

Compared with air drying, the Chem-Dry method requires less time and less space, and results are superior in several ways. Compared with baking, it is faster for many applications, takes less space, costs less, and no heat is required.

Several advantages stem from the fact that no heat is needed. Heat costs money both for fuel and for the equipment to apply it. Most forest products cannot be heated without harming them. It is difficult to bake internal portions of heavy articles. The Chem-Dry process, on the other hand, can treat any part that can be reached by circulated air irrespective of the mass of the article.

Baking is not generally applicable to forest products because elevated temperatures cause undesirable physical and chemical changes. With the Chem-Dry process, no temperature is involved and the hardening agent has little or no action on the material being treated.

Origin of Process

The Meyercord Co. was interested in a quick method for drying ink in the manufacture of decalcomania by lithography. It normally takes about a dozen impressions to build up a decal and each must dry overnight before the next can be applied.

Armour Research Foundation was engaged to investigate all possible methods for rapidly hardening printing ink. These included convection

[1] Presented at Fall Meeting of Northeast Section, FPRS, Nov. 4–5, 1954, in New York City.

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heat, infra-red, ultra-violet light, dielectric heating, ozone, and other chemical agents. The most effective method found was based on the use of sulfur dichloride, powerful chemical which has a rapid hardening action on many resins and oils.

In developing the use of this reagent there were many problems to solve: Which film formers are most effective from the standpoint of speed and properties in the dry coating? What combinations of these materials, pigments, and other ingredients give finishes which can be readily applied, quickly hardened, and produce the desired results? What are the optimum operating conditions for the process itself including such factors as vapor concentration, temperature, time of exposure, and air humidity? What is the best method for building and operating the treating machine so that the sulfur dichloride gas, which has a strong irritating odor, is completely contained within the machine and does not contaminate the working area? What is the best way to minimize the corrosive action of sulfur dichloride on steel and paper? Which of the possible applications are logical and practical ones for the process and which are not?

Development

Many things about formulation as applied to materials for air drying or baking had to be disregarded. The chemical reaction is entirely different and some new rules had to be worked out. It became evident that the best compositions were those prepared particularly for use with the Chem-Dry process.

A number of standard commercial products, formulated originally for air drying or baking, worked rather well. However, the best results were obtained when the coating material was designed to take full advantage of the particular nature of the new hardening method.

It was definitely learned how to contain the sulfur dichloride vapor within the machine and minimize odors carried out by the hardened coating. The treating machine is built in such a way that there is a stream of air from the room entering the openings of the unit, thereby preventing the escape of sulfur dichloride vapors. The odor of sulfur dichloride does not persist in the hardened coating. As a matter of fact, some types of coating materials have less odor when hardened by the Chem-Dry method than when set up by air drying.

Sulfur dichloride vapor reacts with drying oils, oleoresinous varnishes, resins made from drying oils (such as alkyd resins or epoxy esters), rubber, urea-formaldehyde, melamine-formaldehyde, and similar materials. In the case of drying oils, the sulfur dichloride cross-links the molecules at the points of unsaturation. The resultant coating contains both sulfur and chlorine, and the weight of the coating is increased.

In the case of the urea and melamine resins, sulfur dichloride acts as an acid catalyst to initiate the polymerization. The process has no effect on lacquers, solvent type inks, or other coatings which dry by evaporation only. It is not suitable for use with emulsions or water solutions.

Sulfur dichloride can have an adverse action on most metals and certain paper products, especially under high humidity conditions. This is because sulfur dichloride reacts with water to give free sulfur and hydrochloric acid. Materials such as paper and regenerated cellulose must contain certain amounts of water to give the properties required for handling in many operations. If coatings on such materials are dried with sulfur dichloride, there is some hydrochloric acid produced by reaction with the water. This could cause loss of strength and give other undesirable effects.

Ways have been found to minimize this action and in many cases to eliminate it completely. The process can be operated so that there will be little or no loss of strength with most papers and paperboards.

Tested Applications

The process will not harden a thick coating of ink all the way through in a few seconds. It will give an initial surface dryness and completely eliminate offsetting with a coating of any thickness provided the ink or paint is of suitable composition. In the case of coatings containing sizable proportions of very reactive materials such as alkyd resins, the surface absorbs enough sulfur dichloride in the treating chamber to complete the drying within a short time out of contact with the hardening agent. It is not necessary for the coated article to be in the machine more than a few seconds; the hardening action continues in the open air, in a stack, or in a roll.

In the case of inks which are based mainly on bodied oils, at least part of the secondary drying is accomplished by means of air and metallic driers. In the case of thin coatings of reactive inks, the hardening is complete within the treating machine and the ink cannot be smudged even with considerable pressure immediately after treatment.

In the case of oil-base inks or coatings which contain no solvents, it is necessary for sulfur dichloride to work its way through the full thickness of the coating before final hardness is achieved.

In the case of reactive paints or inks containing solvents, two things must happen to complete the hardening. The sulfur dichloride must work its way through the coating and all the solvent must diffuse out. The initial set is achieved even though little or none of the solvent has evaporated, but eventually all of it must leave. The initial action in the treating machine is generally sufficient so that there is no offsetting and sheets can be handled or stacked even though the through-hardening is not complete.

Although the Chem-Dry process will harden thick coatings, this action takes considerably longer than the curing of several thin ones. It is recommended that multiple films which can be hardened all the way through in a few seconds be used to build up the desired thickness. For many applications, a continuous machine can be worked out which will apply coatings one after the other and harden them rapidly with sulfur dichloride.

Coated material resulting from printing, roller coating, brushing, spraying, or dipping is conveyed through a chamber in which a mixture of sulfur dichloride vapor and air is circulated. Air is continuously withdrawn from one end of the chamber, passed through a carburetor where it vaporizes sulfur dichloride, and then back into the other end of the chamber. This maintains the necessary concentration of vapor and creates a definite circulation over the coated articles being treated.

The machine is constructed with guard chambers under suction so that the vapor adhering to the material is removed, and none leaks out into the surrounding air. All air exhausted from the system is scrubbed with alkali solution to remove any remaining vapor.

The process can be used for hardening printing or coatings on articles, sheets, and other materials in a continuous web. Since the machine is essentially an empty treating chamber with a few auxiliary gadgets attached, it can be arranged in almost any form. It is only necessary that the material be in contact with sulfur dichloride vapor for a specific short period of time. The chamber can be mounted horizontally at the end of a press or coating machine if space permits. Otherwise, by means of suitable conveyors, it could be mounted overhead above the application machine. In the case of a continuous web, it could even be mounted vertically.

Finish Properties

With suitable formulations, it is possible to obtain coatings which not only set up rapidly but give good adhesion, toughness, hardness, moisture-resistance, and other desired properties. A characteristic is a complete absence of tackiness to the coating no matter what the weather conditions are. Chem-Dried surfaces are generally harder than those obtained by air drying.

Coatings hardened by the Chem-Dry process have a desirable gradient of properties throughout the thickness of the film from the surface to the stock. It is hard on top, giving good abrasion resistance but is softer and tougher underneath, giving a strong and abuse-resistant bond to the coated article.

Since the Chem-Dry process acts rapidly and "freezes" the coating, it is possible to achieve certain unique effects. For example, a coating can be applied with a roller containing a design and the paint can be hardened so rapidly that the design still exists in the hardened finish. Thick fluid coats of two or more colors can be applied side by side and be hardened before they flow together. If a certain degree of flow-out is desired, this can be accomplished by allowing the articles to stand a few seconds or minutes before conveying them through the hardening machine.

To pre-finish sheets of fir plywood, paint can be applied by a roller coater and the sheets immediately sent through the treating chamber where the coating is set before it can soak into the wood. The differential absorption and grain raising generally associated with fir plywood is eliminated and the panels have a uniform appearance suitable for decoration and other applications where the fir grain is not desired. Thus it is possible to obtain both speed of action and a result not possible by other means.

The Chem-Dry process can be used for hardening paints and varnishes on small wood articles such as pencils, folding rules, toys, and brush backs. Flooring can be rapidly prefinished at the mill by applying a thin film of suitable varnish and hardening by this method.

In finishing furniture, Chem-Drying permits the use of sealers, primers, and varnishes based on alkyd resins which give dried films superior in many respects to lacquers which are now commonly used. The furniture can be sanded or rubbed in a very short time after the finish is applied.

Forest products are associated with the Chem-Dry process in many ways. Tall oil, a by-product from sulfate pulping and an inexpensive base for coatings, has a chemical composition which makes it particularly useful for Chem-Dry paints. The Chem-Dry machine is constructed of plywood since no elevated temperature is required and sulfur dichloride is corrosive to steel in the presence of moisture.

The first unit in commercial operation will process a forest product—wood case pencils. Thus articles made from forest products will be coated with paint from forest products and hardened in a machine made from forest products.

Some of the proposed applications of the Chem-Dry process for finishing or printing forest products are: bags, brush backs, cabinets, cartons, coated paper, containers, desks, display cases, flat panels, flooring, folding boxes, furniture for office, school, laboratory, theater and auditorium, handles, industrial finishing, instrument cases, insulating board, kitchen cabinets, packaging materials, paper products, pencils, plywood panels, prefab components, prefinished lumber, protective and decorative coatings, radio, phonograph, and television cabinets, signs and markers, tables, toys, trailer interiors, and wallboard.

Advantages

1. Coatings are hardened in a few seconds or minutes sufficiently so that the articles can be handled or further processed. They are immediately dust and tack free.

2. Complete surface dryness prevents offsetting and allows stacking of product directly from the treating machine.

3. Bleeding is eliminated, permitting immediate application of other colors or overprint varnish.

4. After application and initial hardening, all components of a finishing system can be cured together in the open air or in the shipping carton. Processes involving several coats can be made continuous.

5. The process permits the use of finishes having high durability and solids content such as those based on alkyd resins, and achieves drying times comparable with high speed lacquers.

6. No heat or fast solvents are required, which means less fire hazard.

7. The cured coatings often have properties superior to those hardened by other means.

8. The coating is hard on the surface and tough and adherent underneath.

9. With porous materials, the coating is hardened before it can soak in excessively, achieving better coverage and higher gloss.

10. Sealers can be hardened before they soak deeply into the wood. This may make it possible to combine the sealer and primer coat. Because of the fast action, there is less difference in absorption by spring and summerwood giving more uniform finishes on wood and plywood panels.

11. Because of the speed of action, it can quickly be determined if there is anything wrong with the finish, method of application, or stock.

12. A speed of hardening equal to or better than baking can be achieved at room temperature. It can be used with articles which, because of their nature, cannot be baked.

13. Less space is required for the drying of the coating.

14. Generally, the cost of drying is less than with conventional methods.

Disadvantages

1. In most cases, it is necessary to modify existing coating formulations to obtain best results.

2. Process is not applicable to lacquers and other coatings which dry by solvent evaporation only.

3. Special equipment is required.

4. Additional evaluation and development is required for some applications.

Summary

The cost of the Chem-Dry process is relatively low considering its many uses. The initial installation may cost from $3,000 up, depending on the size of the unit. The main item of operating expense is the hardening agent, sulfur dichloride, which is consumed in the process. This material is rather inexpensive, about 5 cents per lb., and the quantity used is small.

Many manufacturing coating, or printing processes for forest products operate at high speed. This process is a high speed method which fits in with the philosophy of modern production.

To get the most out of the process, it should not be used just to duplicate what can be done with other drying methods, even though there is a savings in time. It should be employed to take full advantage of its particular nature. It may even be possible to make products by using Chem-Drying that would not otherwise be possible.

General Outlook for the Lumber Industry—Is It A Good Insurance Risk?[1]

JOHN B. GRANTHAM

Managing Director, Oregon Forest Products Laboratory, Corvallis, Oregon

Larger relative increase in price of lumber compared to competing materials is major limitation on anticipated demand in next 20 years. Discusses pressures forcing prices up, measures to hold lumber production costs in line with those of competing materials, and potential markets for mill residues.

IN ORDER TO DIAGNOSE the state of the lumber industry's health and its chances for long life, it is important that the examiners have diagnostic experience. Fortunately a group of 'specialists' recently reviewed the case history of the timber industry and predicted its future health. The 'specialists' report[2] provides a valuable basis for examining the condition of individual industry members. Using this background, the writer would like to examine the insurability of the lumber industry for the next 20 years.

Among other things the specialist's report predicts that:

1. Lumber consumption will increase only slightly between now and 1975, perhaps 7–8 per cent despite an anticipated 64 per cent increase in disposable income of individuals and a 64 per cent increase in new housing starts.

2. Lumber prices are expected to increase about 80 per cent more than the anticipated increase in competitive products. This larger relative increase in the price of lumber as compared with other construction materials is a major limitation on anticipated lumber demand.

Furthermore, the forecast indicates that the price needed to induce more than a 10 per cent increase in lumber production would be so high as to price lumber out of its major markets.

To some it might appear that 1975 would bring a reasonable balance between sawlog supply and lumber demand with a consequent stability of log and lumber prices.

Granted that this is not too gloomy a picture, let us suppose that the forecast of lumber demand was overly optimistic. What can be done to assure that lumber demand will increase even moderately during the next 20 years?

The 'specialists' report predicts that sawmills will use 50 per cent of the total domestic wood in 1975 as compared with the 58 per cent used now; that the increased production of pulp, plywood, hardboard and other products will be made up in several ways without affecting the relative proportion of wood needed for lumber.

Thus, any decrease in lumber output would affect not only the lumber industry but would seriously affect timber production and timber management as well.

Substantial Growth Potential

Clark Heritage, Director of Development for Weyerhaeuser Timber Company, stated in a recent article[3] "The manufacture of lumber is one of the most economic means of converting forest raw material to useful products. I feel very strongly that lumber manufacture is a continuing business of substantial growth potential, provided integrated whole-log use is practiced."

Keep in mind that Mr. Heritage is thoroughly familiar with the pulp and paper industry, having spent a good part of his professional career in that field. Furthermore, his capacity with the Weyerhaeuser Timber Company permits him to evaluate the potentials of other whole-wood products, wood-fiber products, and bark products.

Most of us will agree that the increasing trend toward integrated utilization within the lumber industry is basically desirable. Some pulp and paper men may question the need of integration but even that industry is profiting by an increasing flow of raw material from other wood-processing plants.

If integration is desirable and lumber manufacture is presently the major timber industry, the forecast of its future should be of interest to all.

Pressures for Price Increases

Predictions of future lumber demand hinge largely on price. Present demand would indicate that consumers are reasonably satisfied with value received but pressures are being exerted which could price lumber out of many markets.

The pressures exerted to increase lumber costs include such things as (1) higher stumpage costs, (2) increased logging costs because of smaller volumes per acre, rougher terrain, greater hauling distances, (3) higher milling costs per M board feet because of smaller logs, (4) increased labor costs, and (5) increased transportation costs on the finished products. In some instances competing materials face one or more of the same pressures for price increase, but few are confronted with such a combination of factors.

Offsetting Higher Costs

What measures can be taken to hold the production costs of lumber more nearly in line with the production costs of competing materials?

Many broad courses of action that lead to an improved situation have been undertaken but more activity is needed. Since all of the actions will require years to complete on an industry-wide basis, it is essential that all receive concerted effort. Some of the measures are:

1. Increased integration of timber use by diverting logs to those plants that can obtain the highest values or can most efficiently utilize the raw material. This is not a simple process, even where several plants are under the same management, but the benefits to be gained justify the effort.

2. More automatic equipment is needed in sawmills to increase the man-hour productivity of each worker. Automatic dogging, riderless carriages,

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[1] Presented at meeting of Inland Empire Section, FPRS, Jan. 21, 1955, in Yakima, Wash.

[2] "America's Demand for Wood" 1929–1975. Stanford Research Institute Report to Weyerhaeuser Timber Co., 1954.

[3] Reducing Wood Waste. TAPPI, Vol. 37 No. 8, August, 1954.

The Author: John B. Grantham holds B.S.F. from U. of Washington, M.S. from New York State College of Forestry. He was engaged in retail lumber sales and was associated with Virginia Polytechnic Institute and Texas Forest Service before joining Oregon FPL in 1944. Mr. Grantham was associate professor at Oregon State College in 1946–47, professor and head of department from 1948–52, was appointed to present position in 1953. A charter member of FPRS, he has been member of publications committee since its creation.

remote setworks for resaws, or other equipment that can eliminate men who have no important decisions to make will increase the productivity of essential workers.

3. Equipment designed to handle more efficiently logs of a given size should receive greater consideration. Logging or milling equipment capable of handling a large old-growth log is not efficient for a small log. A greater degree of integration within the lumber industry itself would help the situation. Logs of given size could be diverted to the type of mill designed to break them down most efficiently.

4. Greater volume recovery from each acre of forest land through prelogging or relogging has been accomplished in many instances but the extent of these practices is too limited. Experience indicates that under favorable conditions the volume of wood removed from an acre of forest land may be increased by 20 to 25 per cent. Such increased volume recovery would be of marked benefit in reducing the fixed costs per M on merchantable logs. Utilization of surplus mill residues is needed, however, before substantial gains can be made in the use of all logging residues.

5. The growing network of permanent logging roads improves the opportunities for thinning immature stands and for salvaging fire or bug-killed timber. Values recovered from such operations will help defray the costs of timber production and could provide some measures of relief from high stumpage costs.

6. More effort is needed to increase the utilization of plant residues by expanding uses for slabs, edgings, trims, sawdust, shavings and bark. Although this problem has received the attention of industry and public agencies alike, its magnitude requires still greater effort.

Expanded markets for by-products eventually would increase the return from mill residues thereby achieving the ultimate objective of spreading log costs to products other than lumber. However, the difficulty of accomplishing this goal is illustrated by the results of a recent survey. An inventory of the area within 60 miles of Springfield, Oregon, revealed that there were 2300 tons of chippable sawmill and veneer mill residues available each day 360 days a year.

Materials Developed

Mr. Heritage[4] effectively used a materials balance to illustrate the relative volumes of residues developed in sawing logs. A similar device may serve to illustrate the importance of residue utilization at this point. The table below shows the materials that could be expected in sawing logs containing 20 per cent defect.

The sawmill that has outlets for all residues or by-products is fortunate. Although the return on those materials is not large in comparison with the return on lumber, the use of mill residues as chips or fuel does avoid a disposal cost and may spell the difference between profit and loss for the entire operation. In the above example, the return on residues amounts to about 10 per cent of the total return.

The table is based on many assumptions (including one that products will be sold as listed), but provides a basis for making certain comparisons.

For example, average lumber value is more than 3⅓ times the original cost of logs, on a weight basis, but only 35 per cent of the log is recovered as lumber. Higher recovery values on other products would permit reducing the cost of material charged to lumber manufacture.

[4] Op. cit.

SAWMILL MATERIALS BALANCE AND HYPOTHETICAL VALUES (BASED ON ONE THOUSAND BOARD FEET, NET LOG SCALE)

Materials—to be bought or sold as listed	Solid cubic feet	Estimated weight (dry tons)	Estimated value in dollars		
			Per cu. ft.	Per dry ton	Total
Input			(Cost of logs in pond)		
Logs[1]	200	2.70	$ 0.20	$14.80	$40.00
Output			(Estimated return less manufacturing cost)		
Dry, surfaced lumber	70	0.98	$ 0.69	$49.00	$48.00[2]
Slabs, edgings, trims (green chippable wood)	50	0.72	0.06	4.10	2.94[3]
Shrinkage	8	----	------	------	------
Sawdust 30 Bark 15 Shavings 22 Dry trim 5	72	1.0	.035	2.50	2.50[4]
Totals	200	2.70			$53.44
Average values			$ 0.27	$19.80	

[1] Logs averaging 20 inches in diameter, 32 feet long, 20 per cent defective; $40 per M fbm net log scale, (150 cu ft per M, net log scale; 165 cu ft per M, incl. bark: 35 cu ft defective wood).

[2] At $65 per M less $25 per M manufacturing cost on 1200 fbm (drying and maching losses are accounted for in the $65 per M value).

[3] Based on chips at $7.50 per 2400-pound unit (dry) less $2.50 per unit for barking, chipping and loading costs.

[4] As fuel at $3.00 per ton (dry) less $0.50 per ton for handling and selling cost.

A $10-per-ton recovery value for residues would increase the tabulated values by about $11.50 and permit a $9.50 per M reduction in the material cost chargeable to lumber providing all other factors remained the same.

On the basis of estimated recovery values, only lumber having a value of $8.50 or less per M (rough, green) should be chipped, since a thousand feet of rough green lumber will produce just about one unit of chips.

In view of the still-existing surpluses of slabs, trims, sawdust and other residues, there seems to be no immediate prospect of increased values for such residue materials. It is likely that a buyers' market will exist for several years. However, it does not appear unreasonable that the total value of residues could double within 10 years. Expanded markets are the major need.

Potential Market for Residues

Hardboard and particle-board production is expected to double by 1975. This estimate, which appears to be conservative, is of special interest to the West since 9 of the 12 domestic hardboard plants are located in this region. Furthermore, the two hardboard plants and 7 of the 9 particle-board plants projected for 1955 will be located in the West.

Paper and paperboard consumption in the United States is expected to double between 1952 and 1975. Major expansion is expected in kraft and related pulps that can accept any western softwoods and thus use mill residues from plants sawing a mixture of species. In this field the growing interest in sawdust as a pulp material is of importance. Sawdust may be used to supply short-fibered stock for filling coarse pulps. The West has limited supplies of hardwood timber, normally used to furnish short-fibered pulp, but on the other hand has sawdust in almost unlimited quantities.

Since the sawdust supply is vastly greater than the conceivable pulp demand for this material, it is important to consider other outles of potentially large volume. One which is receiving increased attention is the use of sawdust as a soil amendment. Sawdust is finding increased favor as a mulch for berries, ornamentals, and vegetables such as cabbage and tomatoes. Several efforts are underway to treat sawdust before its application—in order to overcome the temporary nitrogen depletion induced by sawdust—and thereby improve its characteristics as a soil conditioner. If pretreatment can be accomplished at moderate cost, the potential market is vast.

Although the production from sawdust or wood chips of livestock feeds in the form of molasses or yeast is not

now economically attractive, there are possibilities of eventually converting some mill residues to stock feed.

Still another possible agricultural use of mill residues is that of burning bundled slabwood or briquetted shavings and sawdust to protect orchards from frost. Sixteen pounds of dry wood are roughly equivalent to a gallon of oil for orchard heating. Since millions of gallons of oil are burned in orchards during an average year this is a potential outlet of large magnitude for mills in specific areas.

Bark, now used only for fuel, offers a tremendous potential as a chemical raw material. Dr. Kurth's work at the Oregon Forest Products Laboratory has demonstrated that waxes, tannins, and flavanones may be obtained from bark by solvent extraction. The extracted bark itself provides a potential source of chemically-derived products. There presently are scattered examples of bark utilization by such firms as Pacific Lumber Company, Weyerhaeuser Timber Company and Rayonier, Inc., but the bark potential has barely been tapped.

Mention of a few possibilities for large-volume expansion of markets for mill residues indicates that there is a potential for increased returns from by-products of lumber manufacture. However, it is doubtful that during the next 10–20 years this anticipated increase in value will be sufficient to offset cost increases in lumber manufacture. If lumber prices are to hold the line in comparison with competing materials and thereby give reasonable assurance of continued demand, attention must be given to every means of offsetting rising costs.

To those directly concerned with developing new outlets and greater values from mill residues, the long-term insurability of the lumber industry appears good. No cure-all remedy is in sight to ease the ailment of rising costs but several courses of action are open to maintain general health. "Doctors" interested in the welfare of the industry should find much to challenge their ingenuity during the next twenty years. The work should be rewarding because the industry's health is important to the nation and a healthy lumber industry will be capable of paying well for results.

New Developments in Mechanical Equipment for Sawmill Waste Utilization[1]

GUS JACOBSON

President, Soderhamn Machine Manufacturing Co., Talladega, Alabama

Improvements have been made in barkers, chippers, and screens to eliminate problems encountered in initial installations of this equipment. Causes of these problems and their remedies are discussed. New developments in equipment for utilizing sawmill wastes in pulp manufacture are described.

THE FIRST UTILIZATION for paper pulp of sawmill waste produced by independent sawmills in the South was established with installation of the Soderhamn Barker, Chipper, and Screen at the Southern Lumber, Co., Warren, Ark., in February 1952. Prior to this date, the Camp Manufacturing Company operated a sawmill in conjunction with their pulp mill and were utilizing their sawmill waste for pulp manufacture.

Since the pioneering installations of this equipment at Warren, Ark., a number of installations have been completed and are now in successful operation. In 1951, approximately 40 cords[2] of chips were produced daily from sawmill waste by Camp Manufacturing Co., Franklin, Va. In 1952, with the installations at the Southern Lumber Co., the production was raised from 40 to 90 cords per day. As of November 1, 1954, not less than 750 cords of chips per day, or 200,000 cords annually, was being produced from sawmill waste in the South.

This development could not have taken place in such a short time without the financial and technical help which some pulp mills have given 100% to the sawmill industry. This has better equipped the sawmill industry in the South to meet the competition from the West Coast sawmills. It is now a common saying by the lumber men who have installed barkers, chippers, and screening equipment for the recovery of their sawmill waste that they could not have run their sawmills without the additional revenue from the chips, especially during the first quarter of 1954, when the demand for lumber was very low.

The figure of 200,000 cords of chips annually produced by the sawmills represents approximatelv 10% of the number of cords of chips that will be produced in the next five years by the Southern sawmill industry. Perhaps the figure of 2 million cords of chips is too conservative compared with earlier estimates, but it takes into account the economical factor to be encountered with the development of the recovery of sawmill waste, e.g., transportation problems to the pulp mill as well as competition in prices with pulp wood.

In the past two years (1953–54), Soderhamn Machine Manufacturing Co. has made approximately 35 installations of equipment such as barkers, chippers and screens. In 1955, there will be another 25 installations. The machines being produced for these 25 installations are proven machines and standardized as to parts. This firm will also introduce some new developments during 1955. However, we feel it is of utmost importance to make these machines with all the possible improvements. As you know, our company had some problems with the barkers in the first installations. This opportunity is being taken to tell what has been done in the past two years to eliminate these problems and also to bring you up to date on new designs that will soon be available.

Anderson Barker

The main problem with the original machines, installed approximately two years ago, was that they were not built ruggedly enough to withstand the shocks and the strain caused by the rough logs being barked through a

[1] Presented at a meeting of the Florida-Georgia-Alabama Section, FPRS, Oct. 29 and 30, 1954, in Auburn, Ala.

[2] A cord of chips is generally figured at 210 cu. ft. weighing 4,600 to 5,400 lbs. at 50 per cent moisture content, the weight depending on density of the wood.

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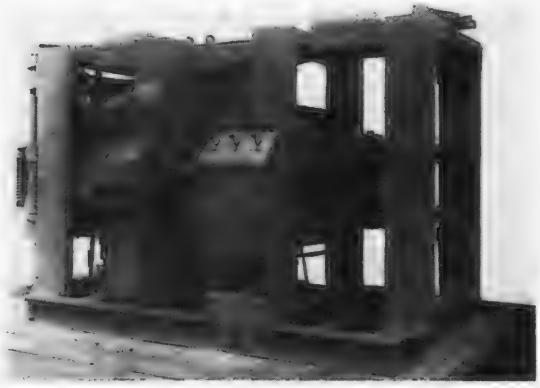

Fig. 1.—Anderson heavy duty barker debarks both hardwoods and softwoods up to 120 linear feet per minute.

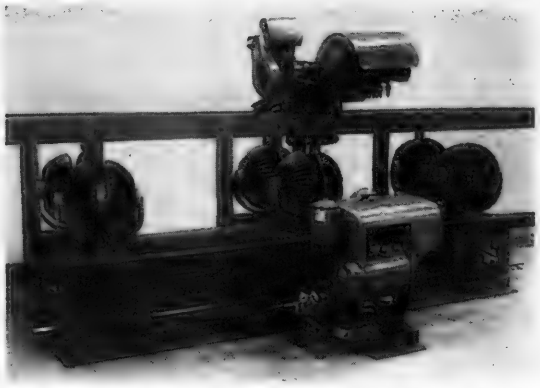

Fig. 2.—D–3 barker is available with cutterhead or new interchangeable articulated head. Handles 8-foot and longer logs at maximum feed speed of 40 linear feet per minute.

rotor barker such as the Anderson. As a comparison, it should be noted that the first Anderson 26-inch Barker weighed approximately 13,000 lbs. and the machine now being built weighs approximately 29,000 lbs.

Naturally, many weak points were found in the barker after approximately six months run. The parts that gave trouble have now been "beefed" up and made easily accessible so that any maintenance on the machine would not shut down the barker installation more than ½ hour. The installation of a heavier feed work cylinder, enabling holding the log as it is being fed through the rotor, eliminated most of the problems and the biggest criticism of the Anderson Barker at that time—the bending of the straight radially mounted tool arms.

The Anderson Barker, first developed in Sweden, was designed to bark softwoods as well as hardwoods, even in frozen condition. It was found that during the winter season a small tool must be used to remove all the bark around a knot. A fact not commonly known is that one of the first Anderson Barkers built used pivoted arms and that the small models incorporated the pivoted arm as early as 1951. The reason for not using the pivoted arms on the Anderson 26-inch machines was that there was not room enough to mount pivoted arms using a tool with a barking surface of 2½ inches. Furthermore, in using woods with stringy bark, it had a tendency to clog up the section of the pivoted arm.

The rotor, an important part of the machine, has been improved tremendously over the first machine introduced on this continent. For instance, shock absorbers have been incorporated around each tool arm cylinder. The latter, by the way, are individually mounted and can easily be replaced in about 10 to 15 minutes. Being able to hold the log and use the heavier tool arm has helped considerably in maintaining this design.

Some installations had the problem of excessive wear on the tool arm or bushings due to the great amount of dirt and grit accumulated. The W. T. Smith Lumber Co. babbits the tool arm bushing, thus eliminating the replacement of bushings and tool arms when excessive wear occurs. No orders have been received from this company for tool arms or bushings during the past year, which proves that their babbit process is working out to satisfaction. This process was passed on to other users of this machine, illustrating the close cooperation between the users and the Soderhamn technical staff.

The Anderson Barker is presently designed with a 2½-inch wide tool to give the best barking results for effectively cleaning even hardwoods all year around. Naturally, in coniferous woods such as Southern pine, wider tools can be used during a certain time of the year. Extensive knowledge of these problems is available from operations in the Northeast, Lake States, and West Coast of the United States, where Anderson Barkers are now being used exclusively on hard woods.

It is difficult to design one machine to do all jobs and it is felt that the limitations of the Anderson Barker have been only on badly rotted and "cat-faced" logs where a hole is bigger and wider than the tool itself. In order to meet the demands and the problems typical to each region of the United States, some machines are being furnished with wider tools and with pivoted arms where such a means of barking is recommendable.

D-3 Barker

A prototype of the first D–3 Barker was shown at the Southern Pine Association Meeting in the spring of 1952. After this first experimental model was shown, numerous improvements were made and the machine standardized as to design with easily replaceable spare parts. The machine has since won wide acclaim by medium size sawmill operators and there now are approximately 12 installations of this machine.

Removal of bark on this machine is accomplished by a cutter head or by an articulated head. The articulated head consists of various means of linkage, but one of the most acceptable one is a head which has a 3-link chain of special steel, developed in cooperation with one of the larger chain manufacturers in this country. The newest development on this particular chain head is a rubber shock absorber which enables elimination of the hitting of the chain on the bolt holding the chain to a round shaft. It has been found that the rubbing action between the links in the chain does not actually wear out the chain. It actually hits the bolt between the chain, which causes maintenance on this chain. The articulated head has eliminated the maintenance problems on the machine due to vibrations which are commonly encountered when using a chain head.

The decision as to the type of head is left to the customer. A cutter head will naturally smooth out a log better than the articulated head; however, the articulated head does not fuzz up the wood, particularly with an experienced operator. The articulated head actually barks as clean a log as any other barker on the market.

Although the cutter head is hydraulically adjustable to regulate the depth of cut, there are some wood losses due to the fact that an operator will fatigue after a certain time. As with any other cutter head type barkers, the wood losses amount to approximately 10 per cent. By using the articulated head, this wood is not lost. To date, purchasers of the D–3 Barker have preferred to use the articulated head. The reason for this is that the revenue received from fibers sold as chips

greatly offsets the cost of replacing the chain once every two weeks.

The cutter head was primarily developed to be installed at round log gang mills to eliminate knots wedging into the saws. However, new developments of the articulated head have made the cutter head obsolete and Mr. Dillingham, the inventor of the machine, has now developed a combination articulated head and a saw which will smooth out logs with protuding knots. Much research is still being conducted to arrive at the best means of removing bark with this machine.

Any new developments on the barking head of the D–3 Barker can easily be installed on the present machines, as all new improvements are made to fit a standardized machine. This barker is primarily designed to be incorporated and installed in a main log haul. The perfect control of a log in the ingenious feed work of this barker enables barking extremely crooked and knotty logs. In order to increase the capacity of this machine, in one instance, this barker is being furnished with a two-speed motor to speed up the logs which are being fed through and rotated in the machine, thus giving twice the capacity when working with a straight log. The slower speed is used on large and knotty logs.

The machine will handle logs from 5 to 36-inches in diameter and, at the present time, bark approximately 700 logs per day, which will serve a 20,000 to 40,000 board foot mill.

Slab Chippers

We manufacture two slab chippers with forced feed—the HF–60 with a spout opening 10″ x 16″, and the HF–30 with a spout opening of 12″ x 7″. This same machine has been used in the Scandinavian countries since 1912 to make quality chips. It has also proven itself in the South and is a machine that is specially designed to make satisfactory chips from sawmill waste.

In order to make all possible improvements to suit the Southern sawmill industry, some new features have been incorporated on this slab chipper. On the feed work, for instance, we have incorporated easily replaceable bushings, and on the chipper discs, wear plates. On the chipper knives, adjustable plates have been incorporated to make an easy change of the machine when manufacturing different size chips required by various pulp mills.

Through the Herty Foundation Laboratory in Savannah, Ga., independently extensive tests have been made from sawmill operations in Arkansas, Alabama, and North Carolina to determine if any other changes of design were warranted. It was found, however, that rigid specifications set by various pulp mills in the South can be met.

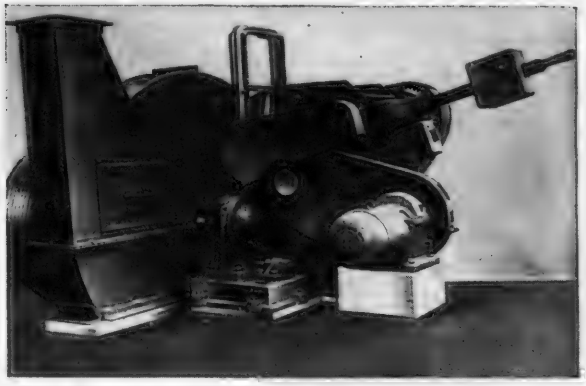

Fig. 3.—New 100-hp HF-60 slab chipper produces 10 cords of chips per hour. This machine will handle round logs, slabs, edgings, cut-offs, box factory and veneer waste.

This slab chipper is used on material typical to any sawmill operation using slab, edgings, and cut-offs. Although not recommended, one operation is using some oversize chips to be re-circulated through the same slab chipper. Typical chip screen analysis from the HF–60 or HF–30 is:

Retain on Screen Mesh
Mesh 1⅛″ — 2.2%
— 1⅛″ ≠ ⅞″ — 11.2%
— ⅞″ ≠ ⅝″ — 27.9%
— ⅝″ ≠ ⅜″ — 39.8%
— ⅜″ ≠ 3/16″ — 18.2%
— 3/16″ — .3%

In order to cut with the long direction of the fiber, which is the type of chips required by pulp manufacturers, it is recommended that users of this equipment do not use shorter pieces than can be fed length-wise into the chipper. Indications from the field are that these chippers have proven themselves from an economical point of view as the chipper is fed automatically without additional labor.

The fly wheel effect of the weight of the cutting discs, as well as the heavy pulley, enables running the chipper from 400 to 500 RPM, which is important. By doing so, the chipper can be installed so that it will replace the hog and utilize the same line shaft drive of the chipper. The low RPM and 45° angle of the chipper makes it possible to minimize the installation costs and reduce the power requirements.

Another important feature is the number of knives—on the HF–60, 4 knives, and on the HF–30, 3 knives. As many sawmills are inexperienced in the proper care and maintenance of knives, this enables them to minimize the time of changing knives as well as guarantee the proper setting of the knives, which is extremely important in the manufacturing of good chips.

Chip Screen

There are a number of chip screens on the market and several different types have been tested in the screening of chips manufactured from sawmill waste. So far as is known, the Soderhamn Chip Screen is the only one originally designed for sawmills.

The problem of screening chips manufactured from pulpwood is quite different compared with screening chips manufactured from sawmill waste. There is always a great amount of sawdust in the processing of lumber and it has a tendency to stick to the lumber as well as the waste material. This makes it necessary to separate the sawdust from the chips, which is accomplished with the double sawdust elimination on this firm's chip screen.

Another aggravating problem is that there are always a certain amount of splinters when using cut-offs, and shorter length slabs and edgings. The Soderhamn chip screen is designed so that the action of the screen can be described as a horizontal circle motion which eliminates splinters from jumping through the coarse screen plates. The screen box is mounted on four steel balls and activated in the horizontal position by a counter-weight mounted on a shaft in the center of the screen base.

This firm manufactures two chip screens—the CS–90 for 15 cords per hour, and the CS–35 for six cords per hour. The machine is quite compact and will run without supervision and maintenance.

New Developments

As a subsidiary of Soderhamns Verkstader AB in Soderhamn, Sweden, our firm has available results of research in wood waste utilization in the Scandinavian countries, Canada, the

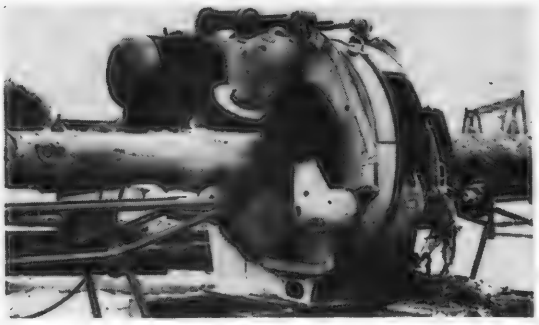

Fig. 4.—New Cambio Barker is first fully automatic machine to bark logs down to 3 feet in length.

Fig. 5.—Tractor mounted Cambio Barker may be used for debarking pulpwood. Machine will handle logs ranging from 2½ to 26 inches in diameter.

United States, and elsewhere. There are certain new developments coming from the Scandinavian countries and the staff in Talladega is trying to evaluate and modify these machines, as well as design new machinery. With the close cooperation of W. R. Warner of the Southern Lumber Co., the International Paper Company, and our subcontractors in Birmingham, redesigning has made the Anderson 26-inch Barker a practical one for operations of this continent.

Also important are the invention and development of the D–3 Barker, which has many new and unique designs and ideas; and the newly invented double log flipper which enables an operator of a barker to flip a log to either side of the outfeed conveyor. This flipper can also be operated fully automatically.

Another important problem has been solved with the chip loading equipment. Two or three different types of chip loading equipment are being marketed, depending on installations and types of transportation to fit each individual installation.

A new development from Sweden, now on the market, is the cambio barker, fully automatic as to feedwork and tools. The shortest length wood fed through this machine is 3 feet, and the present model will take wood ranging from 2½ to 26 inches in diameter.

This machine has a rotor which it is believed will prove effective on Anderson Barkers for sawmills. This rotor will, therefore, be incorporated on these machines after a test period.

These new ideas are a gradual improvement over the present machine and will improve these machines specifically for the problems involved when barking hardwoods. We are all aware of the wider acceptance of hardwoods, even in the South, and it is firmly believed that this new barker will greatly help the industry.

A development that our firm has not taken active part in is slab barkers. We have observed the developments in this field and cannot see a solution for the mechanical slab barkers, not only from a bark removal standpoint but also from the standpoint of the general economics involved when handling slabs and edging strips.

The first installation of a hydraulic slab barker in the South was made in July 1954 at the Clancy Lumber Company slab concentration yard at Decatur, Ala. This is an encouraging undertaking and the average production of this machine is 6½ cords per hour. There will be a few installations of this type in the South in the near future and our firm is working closely with Jackson Industries, Birmingham, Ala., who manufactured the slab barker for Clancy Lumber Company.

It is believed, however, that a hydraulic slab barker should be tested thoroughly, even during the winter season, to determine production rates before the whole story is told of this new development in the South. Perhaps the problem is not a mechanical one, but is an economical problem as to the purchase of slabs, cost of transportation, power, and availability of water.

This field is being watched carefully as there is certainly need for a good mechanical slab barker which most logically could give an independently operating lumberman, or a pulp mill operating a pulp wood concentration yard, an additional machine as a supplement to the present procurement of pulp wood. It is felt, however, that a lumberman has to own or finance so-called "pecker-wood" mills, or own timberlands, in the procurement of material for such a concentration yard.

Our firm has been expanded in the past three years, with personnel and manufacturing services, in order to serve the Southern sawmill industries specializing in wood waste utilization equipment and the development of modern sawmill practices. Complete engineering facilities are available to handle such specific problems as investigation of the heat balance of a mill, log handling, and material flow from the yard into the finished chips loaded into a railroad car or truck. Trained personnel who know the machinery and its operation show the sawmill operators how to best utilize their equipment.

In many instances, sawmills are given written guarantees as to the performance of the machines, for example, to meet chip size specifications set by various pulp mills. These guarantees of assurance of a successful operation, it is felt, have helped in the development of the utilization of sawmill waste.

However, most of the credit for the successful development of utilization of sawmill "leftovers" in the South should be given to the individuals who possessed the vision and took such an active part in the pioneering work to make this important development come true.

Machinery Replacement in the Furniture Plant[1]

PAUL H. GRAHAM
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Discusses the need for machinery replacement, with methods and requirements for proper selection and efficient performance. Analysis of a need for making changes in production facilities may show that new machinery has potential of cost and labor savings, and that a single machine will adequately replace a number of outmoded machines.

OBSOLESCENCE AND UNSUITABILITY are the two outstanding problems of the average furniture plant. This may apply equally to both methods and machinery. In fact, a preliminary study of methods inevitably discloses the shortcomings of the machines.

In the past the average furniture manufacturer has been notoriously prone to a reluctance to try anything new. Most of the machinery and methods eventually adopted have been first tested for a considerable period of time by other industries or by other branches of the forest products industry.

The following warning, credited to The Society for the Advancement of Management, should be hung conspicuously in every furniture plant as a constant reminder of the need for keeping plant policy, methods and machinery up-to-date:

"No War, No Strike, No Depression can so completely and irrevocably destroy an established business as new and better methods, equipment and materials in the hands of an enlightened competitor."

In the current competitive furniture market, it should be quite evident that no furniture manufacturer can hope to long survive if his competitors can beat him in quality, quantity, and price of product through the use of modern machinery, improved methods and labor-saving devices which he could have but doesn't.

Labor and materials are higher than ever before and precision machining of furniture parts is now a prime requirement. The trend in development of woodworking machines has been toward multiple operation machines, automatic machines, and semi-automatic machines adapatable to a wider range of operations and more efficient from point of view of quality and quantity of product produced. These are high-speed precision machines designed to save time, labor, and handling costs.

Modern progressive furniture manufacturers are planning plant layout to place machinery and other equipment at the most strategic points of savings and ease of handling and proper relationship to better plant efficiency.

The cost of manufacturing the furniture product is essentially a combination of cost of labor, materials, management, and other overhead expense. The chief justification for replacement of old machinery is to effect an increase in production to a point where prime costs, materials and labor, are materially reduced.

In most cases it has been the larger furniture manufacturer, with mass production operations, who has taken fullest advantage of new and improved manufacturing facilities currently available. The smaller furniture manufacturer has been more apt to reason complacently that this condition exists because the larger concern is forced to either spend its surplus or turn it back to the Government as tax on excess profits. He seldom feels that investment in new facilities is warranted as long as his present equipment seems to function in a satisfactory manner.

There can be no justification for the use of machinery until it is worn out. In this technological age machines tend to outlive their productive usefulness quickly when compared with the potential production possible with modern machines, and they should be quickly replaced when that point is reached.

Investigation of plants whose management is averse to timely machinery replacement often discloses that management does not know what their outmoded machinery is costing them. On the other hand, the larger furniture manufacturer usually maintains a perpetual study of machine-hour costs which, when used for comparison purposes, permit quick evaluation of new machinery just as soon as it appears on the market.

May Cause Business Failure

It is frequently necessary for the small furniture concern to start with used or rebuilt machinery to reduce the initial cost of the original venture. There comes a point, however, when expanded facilities in the form of additional machines or replacement by machines of improved design and performance are required. If the original machinery is retained in use beyond this critical point, eventual business failure is the usual result.

Reliably rebuilt machinery can be more profitable for the small plant to operate than obsolete worn-out machines which cause frequent bottlenecks with their low production output, work of inferior quality, and requirement of constant repair. Many small furniture plants have embarked upon a sound plant modernization program with replacement machinery of this kind, and have been able to subsequently purchase new machines from savings and increased production obtained from rebulit machines.

Machinery replacement in the small plant usually brings best results in the rough mill, or in single machine operations where work is handled and machined in large quantities, or where a single multi-purpose machine is adapted to a wide variety or combination of operations.

New machinery replacement does not necessarily mean that all older replaced machines need to be discarded or junked. Modern machines can become overloaded during peak periods of production. During these overload periods, the older machines can earn their keep by functioning as standby machines. At other times they may also handle short runs, where it is not profitable to tool and set up the larger production machine. Proper balance of the work load is an important factor

[1] Presented at Annual Meeting of Eastern Canadian Section, FPRS, March 14–16, 1955, in Ottawa, Ontario.

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in efficient machining and other operations in the manufacturing schedule.

Before machinery is replaced, or new methods are adopted, due consideration should be given to what machines and what methods are best suited for the volume and type of product manufactured. Special consideration should be given to quality requirements, size and frequency of machine runs, variety and range of product to be manufactured, materials from which the product is to be made, and anticipated expansion in future years.

Replacement machinery should be selected to meet maximum requirements plus slightly larger capacity to assure longer service. Machine capacity should also be measured in quality of production.

Mere technical improvement cannot be regarded as sufficient reason for the purchase of new machines. It is imperative that the cost of any proposed changes be balanced against anticipated resultant savings. The question to be answered is not only "Will the replacement machine and new method work better?", but also "How soon will it pay for itself?".

Planning Machine Replacement

Lacking an organized plan for machinery replacement, a good starting point to determine which machines should be replaced is to first select just those machines in the plant that are more than 10 years old. It is surprising how many machines in current use are much older.

Study the woodworking machinery market to select not only those machines which perform similar operations but also single multi-purpose machines which combine a number of operations in a single unit.

Compare the projected capacity of these machines against those in present use. If increased production and savings are indicated as possible with the new machine, then analyze its installed cost and estimated operating cost in comparison with the known cost of machines in current plant operations.

This study is normally based on a depreciation of about 10 per cent annually. Charges, such as insurance, interest and taxes, depreciate as machine value decreases for a normal average of 5 per cent over the normal 10-year depreciation period. Thus, replacement machinery investment charges become about 15 per cent. Operating costs are generally calculated on the basis of operator cost per hour and power cost per kilowatt hour. Tool life and cost is usually estimated and prorated over the same period.

Although some concerns include fixed overhead charges, such as lights, floor space rental, etc., in their comparative estimate, others reason that reduction in direct labor cost by the new machine does not necessarily involve substantial reduction in overhead costs. They believe that conservative estimating requires comparison on direct labor only. This does not apply, of course, if overhead rates on a machine are figured on an hourly basis, where substantial reduction in machining time would naturally reduce the overhead cost.

Some furniture manufacturers base their decision to purchase replacement machinery upon the capacity of this equipment to pay for itself out of operation savings in two years. Others set up an earning requirement of 20 per cent calculated on the basis of monthly operation. For example, where the combined depreciation and 20 per cent annual earnings total $600, the new machine would be required to show a potential earning of $50 monthly.

It should be remembered, however, that many machines in the furniture plant are used on the majority of products manufactured so that changes in design of product do not necessarily render the machine obsolete. In such cases the period over which the new machine should pay for itself can be safely extended over a much longer time than a machine of specialized design and function.

The purchase price plus installation cost of the replacement machine can be calculated with reasonable accuracy. Unit cost of the current operation involved can usually be determined from past experience contained in time standards and production records. An approximate cost of the proposed replacement can be arrived at from the machinery manufacturer's production figures. To find out how soon the machine will pay for itself essentially involves the quantities of product and frequency it will be put through the machine over a given period of time.

A total of estimated machinery investment charges and operating costs divided by the number of hours the machine will be in operation in a normal year will provide hourly operating cost for use in comparison with known production costs of the machine in current use.

Due consideration should also be given to capacity requirements of general plant production. It is essential that the new machine not only reduces cost of the operation but enough work must be supplied in normal flow of production to insure adequate return on the original investment.

A modern high-speed modern machine may have capacity to treble the production of the machine to be replaced but if runs are too short, or the total unit requirement of general plant production is relatively small, the more expensive replacement machine may not be in operation enough of the time to permit amortization within a reasonable length of time. This can tie up capital in machine investment that might be put to more profitable use.

Proper Work Balance

There has been a tendency on the part of some machinery sales engineers to oversell machine capacity instead of tailoring it to suit production requirements of the individual plant. It is well to anticipate reasonable expansion of production, made possible by modern machinery replacement, but if machine capacity is considerably excessive, the machine will be idle much of the time, or additional auxiliary machine equipment will be required to bring production into proper work balance.

A case in point occurred in a small furniture plant which purchased a large automatic shaper with production capacity sufficient to replace three hand shapers. Analysis of the first year's operation showed that while 1,875 hours had been previously required to meet the annual requirements of 150,000 units, the automatic shaper produced this volume of product in just 420 hours. So much idle machine time was indicated that it was estimated that it would take about 18½ years for the machine to pay for itself.

Lest the reluctant furniture manufacturer seize upon this reference as a major argument against any need for machinery replacement, it should be pointed out that there is a condition which will offset the excess work capacity problem which permits the smaller plant to enjoy the benefits of the modern high-speer automatic machine. Other plants within convenient delivery distance of the user-plant might possibly use part of the excess work capacity at a price that would help defray the purchase price and continued operation of the machine. Operations of this type anticipate sale of this machine time to outside plants at about three times its actual cost, which should result in a substantial profit.

Another factor which should be considered when purchase of replacement machinery is contemplated, is that the quality of product turned out by present inferior equipment may require expensive additional operations, such as extra sanding after a poor surfacing job at the planer to properly prepare the surface for subsequent finishing operations. Also, the new machine may have capacity to eliminate some opera-

tions previously required at different machines. For example, an automatic shaper replacing a hand shaper may eliminate preliminary bandsawing previously required before shaping.

Preliminary studies of the various factors often result in the purchase by the small plant of a single multi-purpose machine that is adapted to a wide range of operations performed singly or in combination operation. Notable in this connection is the double-end tenoner.

There are few furniture parts which cannot be machined at the double-end tenoner, when the machine is properly equipped with auxiliary tools and attachments. It permits a combination of operations, resulting in less handling, faster machining, reduced congestion, and lower unit costs. Even when runs are not of large volume, the multiplicity of operations that can be performed on this machine often make it more economical to have the work done on this machine, even in the small furniture plant, than on a number of smaller machines, as added set-up time is more than offset by savings made.

Longer set-up time required is an argument used by some opponents to the use of modern automatic machinery. Actually, the set-up time required by these machines depends mainly upon the skill and experience of the operator.

A study of automatic shaper operations, with a skilled operator, involving the shaping of furniture parts recorded only 15 minutes to set the machine up for a new job, where only the forms had to be changed; 30 minutes when the shaper table had to be cleared and a complete set-up was made; up to one hour, for radical changes involving replacement and movement of the air clamps.

The larger furniture manufacturer leans toward the purchase of specialized machines capable of high speed production in single or combination operation. Typical of the specialized machine is an automatic dovetailing and boring machine which cuts up to 12 dovetails on each end in a single operation, while individual adjustable bits bore holes required for drawer pulls. Operating with automatic preselected cycles, an average 12 drawer fronts per minute are produced, completely dovetailed and bored.

Proper placement in the production line is required to realize greatest return from machinery replacement. Well balanced production may not require machines with highest speeds but rather those that will keep pace with or set pace for other machines that can be maintained throughout the plant.

Machine flexibility or ability to adapt the machine to a variety of operations may be the most important element of comparison. When the flexibility of a smaller machine reduces work space and permits more simple arrangement for efficient handling of materials, possible savings may well offset theoretical savings credited to the larger or faster machine for the same job. Where space requirements of a large multi-purpose machin require moving of many other machines, several smaller units of single-purpose type strategically located may be better than the single large machine.

It is false economy to purchase the best machinery available and employ skilled operators unless proper means are provided for supplying these men and machines with materials that are modern and efficient. Processing and handling must be intelligently and skillfully coordinated for best results. This involves discussion of materials handling that is too lengthy a subject to be handled in this paper.

A common mistake made by the furniture manufacturer who suddenly realizes the importance of proper machinery replacement in his plant, is an attempt to copy methods and machinery used in other plants, without first making a complete analysis of conditions prevailing in his own plant. Each plant and furniture product presents its own peculiar problems. General operating policies may be adopted with success from similar plant operations but individual applications must be tailored to meet problems and conditions of the particular plant.

It is also true that the most efficient cost and production control system available will not correct improper or inadequate plant layout or production methods. This type of control serves to point up deviations from standard conditions it is set up to control. In this function it is an efficient tool of management but its intrinsic value is realized only after the plant has been laid out to operate on an efficient basis.

The best approach to a sound machinery replacement program would seem to be through the use of sound cost and operating data and competent engineering counsel that is capable of providing management with adequate and reliable information regarding the advisability of making changes in current production facilities.

It is barely possible that such an analysis will show that the initial investment, represented by the purchase of replacement machinery, will be unwarranted when compared with current production and direct labor costs. The chances are far greater that it will show the purchase of new machinery has a potential of both cost and labor savings, and in many instances, that a single machine will adequately replace a number of outmoded machines.

The open-minded furniture manufacturer who will take time to look around his plant, study and investigate all factors involved in the manufacture of his product, find out what facilities his successful competitors are using, inform himself about all new and improved machinery, handling equipment and other facilities now available, test new materials—raw and service materials, and investigate what research is being conducted in his particular field, will visualize and realize for his furniture product better quality, greater production, reduced costs, and substantial profits.

Tomorrow's Products from the Trees of Today[1]

HENRY P. GLASS

Designer, Glass-Huebner Associates, Chicago, Ill.

Several potential new uses for wood products in the home furnishings and construction fields are described. The author suggests that wood and steel members be used in combination, as in reinforced concrete, taking advantage of the best properties of both materials. He also points out that the industry should not try to force its way into markets where wood does not belong, but should concentrate on development of superior wood surfaces which will overcome competition from materials imitating wood.

SINCE MAN INVENTED THE TREE HUT, which long antedated the cave dwelling, our earliest ancestors lived in trees. Today we still cultivate that habit and it is doubtful if our descendants will ever abandon it. We don't build our domiciles out of branches and limbs and live in the crowns of tall trees, but we are improving on nature by much more intricate means. This means employing the materials, brains, and ingenuity given to us to the best of our advantage.

We have learned to fell logs, cut them into timbers and boards for structural members and for the skin of our shelter. We have learned to slice thin layers of beautifully figured woods into flitches of veneer and apply these layers to home furnishings for the satisfaction of our aesthetic senses and for the structural improvement of wooden panels of all kinds. We have found that the undesirable properties of lumber, such as hygroscopic instability, can be overcome to a great extent by crossbanding layers with adhesives to form a new material with much better properties—plywood.

All these things simply show that the main aim of any scientific or research endeavor which is aimed at the betterment of human living conditions is nothing but an attempt to improve on nature. Members of FPRS are attempting to improve on the products of the forest. Decades of diligent work and concentrated effort have been devoted to this problem and the accumulated knowledge in this field is based on centuries, probably milleniums, of human experience.

In the past, the author has been faced with various issues particular to certain industries and was able to, if not solve entire problems, at least sparkplug thoughts which lead to their solution, by shear virtue of an entirely fresh, unprejudiced approach. The following ideas are presented in the belief they could become marketable and successful wood products. Possibly some of these suggestions may have already been tried and proved uneconomical or unacceptable. Others might be in development or already on the market. A few might be the proverbial golden grains found by a blind hen.

Plywood Curvatures

Many attempts have been made at processes to create deep three-dimensional curvatures in plywood to compete with deep-drawn metal stampings for stressed skin construction. All such processes invariably necessitate a great amount of individual hand labor. The layers have to be applied in narrow strips, rather than in large sheets, and this requires time and skill, and consequently money. The production of the famous Canadian mosquito bomber was only possible in a strict wartime economy, aggravated by an acute metal shortage.

Frankly, it is amazing that the simple process of bending plywood is being utilized so little in the industry. It is common knowledge that bends stiffen any sheet material, besides giving it many different potential applications. One of the wood derivates, Masonite, is available in standardized bent shapes and is widely used for display, background screens, and even furniture. Why is there no plywood of thin sheets bent to standard shapes for similar purposes? There is corrugated metal, glass, and plastic of all kinds. Why is there no corrugated wood, which should have widespread acceptance? Even steam-bent pieces of solid lumber should be made available in a wider and more varied range. Eager customers would be found among chair manufacturers.

Another suggestion is perforated veneer or thin two and three-layer plywood. It is true that one pattern of perforated wood is available, but the field is wide open for innumerable other patterns and designs to be used with open perforations for loudspeaker screens, radiator enclosures, air grilles, etc. By laminating over chipcore, fiberglass, cellotex, and other porous materials, the product could be successfully used for acoustical wall and ceiling panels.

Striated plywood has been on the market for several years and has been a fabulous success, as has sand-blasted plywood. Why is there no plywood available which is scored deep enough on both sides so that the lines not only form a welcome decorative element, evening out undesirable wild grain, but also permitting the sheets to be bent and applied to concave and convex surfaces.

The fashion trend seems to be hungry for texture, yet the producers of many wood or wood by-products appear ashamed of their products' texture. They seem to feel as though they have to hide the products under the formal gown of fine veneer or other surface materials. Chipcore is one of these products. Manufactured from mill residues, chipcore possesses a pleasant, almost marble-like surface. If it could be coated by wear-resistant transparent resins, it would make an acceptable, beautiful, and resilient floor tile.

Another potential is in panels made of thin strips of solid lumber laminated side by side, instead of in layers like plywood. Such a construction is frequently used in solid lumber core. If made in sufficiently narrow strips, although it might not have the dimensional stability of plywood, it still could be commercially acceptable in small panels for cabinet tops, drawer fronts, sides, etc. It could be produced from fall-off strips or other waste. Due to its linear arrangement, it would

[1] Presented at Annual Meeting, Midwest Section, FPRS, Sept. 23-24, 1954, in Madison, Wis.

The Author: Henry P. Glass is a graduate of the Architectural College of Vienna, received Master's degree in architecture from the Theiss School. He practiced architecture in Austria and Czechoslovakia until 1939, when he entered the U. S. He has since been associated with several of the country's leading architects and designers. In 1945 Glass joined the faculty of the School of Art Institute, Chicago. He formed his own firm in 1946 and joined in partnership with L. H. Huebner in 1951.

never show wild grain, but it would present an irregularly striped texture which might be promoted into a fashion trend.

A possible outlet for solid hardwoods in limited quantities would be a line of smartly designed wooden cabinet hardware. Various shapes of pulls and escutcheons produced by sticker-molding and carving machines, as well as wooden hinges and door butts of bent plywood, might become a distinctive trend.

How about a system of egg-crate and sales counter dividers in thin plywood? These would be unbreakable and in many ways preferable to the present glass and plastic dividers.

Another idea is a material consisting of woven strips of veneer of various widths and species, plastic coated to give it stability and sturdiness. Imagine the interesting basket weave and plaid effects which could be achieved. Such a material would have practically limitless decorative applicability on screens, cabinet fronts, door panels, lamp shades, window blinds, place mats, waste baskets, and a host of other accessories.

Combine with Steel

Thus far, any possible new structural applications of wood products have not been mentioned. Several progressive firms throughout the country are manufacturing laminated beams, trusses, and columns. Although vastly superior in strength-weight relationship to unlaminated members with equal dimensions, they are still limited by the inherent maximum tensile strength of the wood fiber. Why couldn't steel and wood members be used in combination like they are in reinforced concrete, which combines the best properties of both materials? It is conceivable that half-round grooves could be routed out in adjacent laminations and steel rods inserted as tension members and glued right into the beam or truss. The finished structure could even be pre-stressed to minimize deformation under load by the tightening of anchor bolts on the protruding ends of such reinforcement members. In like manner, the load bearing performance of columns could be vastly increased by the insertion of steel pipes.

In a recent issue of the Journal of FPRS, a member wrote: "What have we done to remind Mrs. Consumer that T. V. is not an appliance, but is actually a key piece of furniture?" It should be pointed out that architects and designers are doing something about it to the point where the question is now slightly obsolete for two reasons:

A practical application of wood and metal in combination is this line of school and institutional furniture designed by Glass–Huebner Associates. Chipcore, plywood, plastic, and steel are used. This line brought firm an honor award from Fine Hardwoods Association.

1. It is unjustifiable defeatism to consider the field of appliances tabu for the wood product market, especially in a time and age where the all-steel kitchen, dominant a few years ago, is fighting a losing battle in a war which started with the first open plans for the 20th century one-family dwelling for low and average income groups.

First the dining area returned to the kitchen and to match the latter it became an all steel dinette. In recent years, however, the dining area has been returning to the living room, where it had been in the highly functional home of the early American settlers. Here we have, to again quote the article, "the innate fondness of the American consumer for genuine wood" on our side. There is no danger of the American living room going all steel, all aluminum, all plastic, or even all titanium, the latest miracle metal. On the contrary, there is good reason to believe that the kitchen will go all wood. You already see more and more beautiful pine and mahogany kitchens with stoves, sinks, and refrigerators sticking out like sore thumbs. However, you also see advanced kitchen concepts, where all appliances are built into wooden cabinets with visible metal parts reduced to small, insignificant, but neat escutcheons.

2. The concept of "a piece of furniture" is also on the way out. This may sound strange, especially coming from a furniture designer. But it is a designer's business to watch all trends in all fields: social habits, technological and industrial developments, merchandising as well as economic swings, and public taste preferences. This should enable us to decipher handwritings on various walls a little earlier than common mortals. In this instance, I am referring to storage walls.

A few decades ago, houses and apartments were built without closets. People stored their clothing and other possessions in huge wardrobe chests. Some of these were magnificent pieces of cabinetry, sculpture, painting, and other applied arts. Some are still available as costly antiques and are used for strictly decorative purposes. Like it or not, the wardrobe cabinet as a utilitarian piece of furniture is as dead as the free-standing bathtub or high-legged kitchen stove or sink. Today, built-in kitchen storage cabinets of wood or steel are required minimum standards. So is, of course, the walk-in storage closet, but the latter is an inadequate solution.

Storage Walls

The architect has again invaded the home furnishings field and has come up with the much more practical principle of the built-in wardrobe—an area 2 feet deep, 7 feet high, and as long as necessary. It is completely accessible by means of large sliding door panels. Some have even gone farther and have incorporated drawers, sliding shelves, and storage compartments for all kinds of uses.

Called a storage wall, it has not met with widespread acceptance, mainly for economic reasons. Since public demand so far has been strictly potential and not a proven fact, no manufacturers have gone into large-scale production of storage walls. Although owners of existing installations are extremely satisfied, the storage

walls had to be custom-built and consequently the high cost scares away many potential customers. Also, many installations were put together with inadequate materials, leaving much to be desired in fine fit and workmanship.

Better panels are being developed—more reasonable, warp-proof, and prefinished. The trend of consumer preference towards built-in storage is ever increasing. Every shelter magazine contains large spreads on this subject. Thus you have improved materials on one side and increasing consumer demand on the other. When one clever builder puts storage walls into his homes or apartments, competition will be established and others will have to follow suit. The public will demand complete home utility filing systems as efficient as the file cabinets in your offices. The latter, by the way, will have wooden shells and fronts before long, although it is believed that they will have steel chassis and steel drawer extension slides with nylon rollers.

This inevitable development of universal, built-in home storage will practically wipe out case goods manufacturing as we know it today. But it certainly will not seriously hurt the case goods manufacturer—it will just change his market picture. He will build modular units for drawer cabinets, shelves, radio, T.V., record player, storage, and many more uses. They will be shipped K. D. directly to the building site like standard doors and windows. The case goods manufacturer will sell to the builder or architect rather than to the furniture or department store. These dealers might have to do a little shifting and re-adjusting, but in this marvelous system of free enterprise, progress is always for the better. The furniture dealers of today may sell prefabricated homes tomorrow.

A recent article raised the question: "What would have been your guess about the effect of electricity when it was first introduced? Would you say it would ruin the candle manufacturing industry and cut deeply into the territory of those who sold gas?" Most people thought it would, but here are some surprising figures. In 1914 candle manufacturers employed 387 workers and paid them $183,000. In 1947 this industry employed 2,405 people and paid them $3.7 million. In the borough of Manhattan, 5.155 billion cubic feet of gas was sold in 1883. By 1950, gas consumption had increased to 25.874 billion cubic feet. In the meantime, of course, electricity was providing thousands of jobs and additional comforts for everyone.

The inevitable trend to complete storage walls and the vastly increased wood surfaces which will be minimum requirements in every home will be a terrific boom to the forest products industry. Add to this the ever increasing preference for paneling of walls in living room, den, and recreation room, the fondness of many architects and their followers for expressed structure, such as wooden beams, timber ceilings, inside columns, the return to the parquet floor, and last but not least the almost complete eclipse of the electric fireplace. A lot of wood is consumed in wood-burning fireplaces, and that too is good utilization of forest products.

Conclusion

The forests of the earth give us a wonderful product in millions of shapes, forms, colors, and textures. However, other products are no less wonderful—and metals and plastics are not exceptions. There are many old and many more new wonderful possibilities for making wood products serve mankind. You don't have to be jealous of others and you don't have to try to force your way into markets where wood simply does not belong. Let's concentrate on the development of a wood surface with all the wear, acid, and heat-resisting properties of plastic for a price no higher than the latter, and this will deal a death blow to all the photographic fakers and imitators. You don't have counterfeiters where the cost of home production of bank notes exceeds their face value.

On the other hand, don't hesitate to use and promote the application of other materials in combination with forest products. Wherever other materials give better value in themselves, they enhance the beauty and value of wood products. As mentioned before, the steel chassis, extruded drawer slides, nylon rollers and bearings, and deep compression molded drawer bins are here to stay. Just like in the candle industry, their final result will be an increased and more sensible use of forest products.

Kiln Degrade as a Result of Improper Manufacture[1]

ERNEST OLIVER

Dry Kiln Engineer, Pratt, Read & Co., Inc., Ivoryton, Conn.

KILN OPERATORS get blamed for many "end conditions" of kiln-dried lumber that are possibly not their fault. Thus they should be on the lookout for adverse conditions in the lumber going into the kilns, to see if there is anything that can be done to improve them.

The following items can be classified as improperly manufactured lumber:

1. Miscut lumber—extra thick or "wedges".
2. Miscut lumber—thick at the middle and thin on the ends.
3. Lumber that has been sawed through and through (more or less).

A primary objective is to minimize degrade and improve the overall condition of the kiln-dried product. Basically, yard sorting procedures should be initiated that will alleviate these previous conditions.

All extra thick boards (item 1) should be sorted into a single pile and then dried as thicker material, if possible. By having them segregated, they are not able to distort the other boards as they would if left mixed in.

Item 2 usually is corrected by using thicker stickers on the ends of the kiln loads. Depending on the general degree of variance, regular insertion of thicker stickers every few courses can be arranged, or it can be done on a measurement basis. This improvement will help to provide flat boards.

Item 3 will usually not be improved by piling. A kiln schedule that will create as much early set as possible will help.

[1] Presented at a meeting of the Northeast Section, Forest Products Research Society, Nov. 4–5, 1954, in New York City.

Controlled-Air-Seasoning of Wood for Preservative Treatment[1]

J. A. VAUGHAN

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A method[2] was developed for seasoning wood to moisture contents necessary for subsequent preservative treatment. Heat input and volume of air vary automatically and maintain relatively constant rate of removal of moisture from charge. Satisfactory drying schedules and average monthly production rates are reported.

ANYONE DEALING IN FOREST PRODUCTS is sure to be confronted with the problem of drying these for some specialized or even general use.

Those dealing in lumber stocks three inches or less in thickness may quickly and safely season this lumber to a moisture content of about 25 per cent by natural air seasoning. If use requirements demand a moisture content below 12 per cent, means have been developed for doing this in dry kilns.

Of course, dry kilns call for considerable investment and operation costs are relatively high, even though the heat may be supplied entirely by mill waste. The dried lumber brings a better price, however, so that in the end everyone benefits.

The wood-preserving industry, which is one of the largest wood-using divisions of the forest products industry, does not find the problem quite as simple as has just been stated.

The wood preserver is faced with a multiple problem. In the first place he deals with sizes ranging from 1-inch boards to 12- x 12-inch timbers and even 14-inch butt diameter poles and piling. Second, he may have to handle pine, oak, gum, and fir. Third, his customer does not, except for a few items, specify that he must dry his materials to a specified moisture content and the customer offers no additional price for dried or seasoned lumber.

Air seasoning is considered by many to be the best, easiest, and most economical method that may be employed for drying wood. Certainly it has many advantages. All know, however, that natural air seasoning has its faults and presents some serious problems. Under ideal air-seasoning conditions, all species of wood may be seasoned successfully and in reasonable time.

Unfortunately ideal weather conditions do not usually continue over an extended period in any but a few isolated locations. Seasonal conditions vary greatly as do daily conditions within the same season. Night conditions are quite unlike daytime conditions. Because of these variable and uncontrollable factors, natural air seasoning has its hazards and problems.

Since even under the best of drying conditions several months may be required to naturally air season wood for treatment, the wood preserver finds that unless very large stocks are maintained, production schedules often suffer. If he carries large stocks, the hazard of decay is always present. It will be seen that the problem and the hazard go hand in hand.

Only a limited number of species of wood may be successfully steam-and-vacuum conditioned; therefore the wood preserver cannot rely wholly on the treatment of green wood. Even though he could condition all species in this manner, here again he would run into an economic problem since more cylinder time is required for the combined conditioning and treatment and resultant weights are much higher than for dried material.

Drying of wood has thus become a major wood-preserving problem. The desire and necessity for dry and assured sound wood for treating purposes have encouraged the wood-preserving industry to seek artificial means of seasoning the items they supply.

Although a number of artificial seasoning methods have been suggested for drying wood prior to treatment, current practice indicates that the average wood preserver uses none of these but continues to rely wholly on natural air seasoning, steam-and-vacuum conditioning, or Boultonizing.

There are a number of valid reasons why the present-day wood preserver should desire a safe, practical method for drying the timber he is to treat. From his own standpoint, there is the conservation of cylinder treating time. Further, there are items such as crossarms or wood blocks for interior floors in which the customer, contrary to usual custom, specifies a moisture content of not over 20 per cent. This latter requirement is difficult if not impossible to meet by natural air seasoning in some localities or during certain weather cycles in almost any location.

Both the treater and the consumer of preserved wood stand to gain a large measure of security from artificial seasoning methods. These, if successful, give assurance of sound timber, fast production, and low moisture content without the hazards of decay.

The mill operator's problems in drying may be somewhat different from those of the wood preserver. On the other hand, since both have drying problems and both are interested in obtaining seasoned timber without fear of natural air-seasoning hazards, then the process of Controlled-Air-

Fig. 1.—Double-run or U type Controlled-Air-Seasoning unit, showing fan and air heater housing.

[1] Presented at a meeting of the Florida-Georgia-Alabama Section, FPRS, Oct. 29 and 30, 1954, in Auburn; Ala.

[2] U. S. Patent 2,706,344, other patents pending.

The Author: J. A. Vaughan holds B.S. in applied chemistry from Virginia Polytechnic Institute. Director of Research at Southern Wood Preserving Co. since 1930, he was formerly associated with duPont de Nemours, Chemical Warfare Service, Norfolk and Western Railway, and American Creosote Co., Vaughan is a charter member of FPRS.

Seasoning should be of interest to mill operators also.

Initial Studies

Some 16 or 17 years ago the Research Department of Southern Wood Preserving Company began intensive studies of artificial means of drying wood for subsequent preservative treatment. It was proposed primarily to dry green pine poles (80 to 100 per cent moisture) to good treating condition (approximately 40 per cent moisture) in a relatively short time.

The first attempts were performed in a standard cross-circulating dry kiln and various dry kiln schedules were employed. About the same time, the Bell Telephone Laboratories[3, 4] performed similar experiments.

Both were successful in obtaining dry pine poles (40 to 45 per cent moisture) in a reasonable drying time, but each learned that poles dried in this manner treated erratically and showed a marked tendency toward severe bleeding following treatment.

A thorough study of these facts clearly indicated procedures in other directions, both in regard to type of drying equipment and drying schedules to be used. Repeated research and experimentation finally led to the current Controlled-Air-Seasoning process and units.

Design of Units

The cross section and length of the units were designed with the following considerations: the species and size of material to be dried, the drying capacity desired, the operating schedules which must be followed for a particular species and size, and the economics of handling and processing.

Where yard space and proper handling equipment permit, it is best to construct the units simply as long, narrow, low buildings, usually well insulated, and of any material that will prove economical in both first cost and maintenance costs. If lift trucks will handle the material to be dried or if C-A-S[5] units are located where space and handling equipment such as locomotive cranes are available, the straight-run single unit is perferred.

Sometimes, however, long clear areas are not available, the material to be handled is large, and no locomotive equipment is available. At such times it may become necessary to build stationary crane or lifting equipment. To avoid duplication of this equipment, it is advisable to build the units in the form of a square end "U", the material moving down one side, being moved on a transfer table to the opposite side, and being unloaded at the same end of the unit at which it was charged.

Every unit, whether a straight-run or a U type, is considered to have a hot end and a cold end. A source of heat is installed on one end and a fan for moving air through the unit on the other. The fan and heat source may actually be mounted on the same end depending upon whether a forced draft or an induced draft system is desired.

The degree of heat employed through the system is usually regulated by automatic controls, but may be operated manually. Controls also regulate the flow and volume of air passing through the unit. This control is in response to air volume and heat needs during the drying of the particular material involved.

The material may be moved through the unit on trams of suitable design or may be moved on conveyors. The material moves from the cooler to the warmer end of the unit at a rate depending upon the cycle required for species, size and shape of timbers, and final moisture content desired.

It should be pointed out that Controlled-Air-Seasoning should not be confused with kiln drying. Both of them aim to condition wood or other materials from a higher to a lower moisture content. Generally kiln drying is aiming at moisture contents below 15 per cent and handles material of relatively small cross section. Controlled-Air-Seasoning aims at moisture contents suitable for satisfactory treating purposes, and is seldom proposed to dry wood lower than about 20 per cent.

The principles of the two operations are basically different. In standard dry-kiln schedules and operation, the temperature, heat input, relative humidity of the drying air, and volume of air employed are predetermined and manually reset from time to time as the materials dry and sampling indicates a change in conditions is needed.

In Controlled-Air-Seasoning, the drying wood sets its own conditions of heat input and air flow in response to the rates at which water is being given up by the wood at any instant. The maximum temperature of operation may be manually set but the heat input and volume of air vary as the rate of drying of the wood signals that such changes are necessary to either increase or decrease evaporation and thus maintain a relatively constant removal of moisture from the charge as a whole. These fully automatic controls assure scheduled drying under conditions most favorable for satisfactory and economical seasoning. In Controlled-Air-Seasoning, the total artificial input of heat is utilized except in very cold weather. In addition, there are daily periods as well as seasonal periods during which some of the atmospheric heat may be utilized.

After the Controlled-Air-Seasoning unit is initially fully charged with the species and type of material to be seasoned, a cycle schedule will be established. Schedules which have thus far proven satisfactory for drying green wood to treating condition are as follows: southern pine poles and timber, 8 to 10 days to 40 per cent; gum crossties and switchties, 16 to 20 days to 50 per cent; and southern pine lumber from 3 to 5 inches thick, 16 to 18 days to 20 per cent.

Economical size units will produce, on a monthly basis, 60,000 to 75,000 cubic feet of southern pine poles; 320,000 to 500,000 board feet of lumber; or 12,000 to 18,000 gum crossties.

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[3] Segelken, J. G. 1941. Kiln drying long leaf southern pine poles. AWPA Proc. 37: 135. Comments by J. A. Vaughan.

[4] Segelken, J. G. 1942. Kiln drying southern pine poles. AWPA Proc. 38: 251.

[5] Registered trade mark.

Around the World in Forest Products Research and Development

Scanning World-Wide Forest Publications

Norsk Skogindustri. V. 9, No. 8, August 1955. Diffusion of Sodium Chloride in Wood Fibre Boards and Plywood: Part 1—Diffusion through Hardboards, Wood and Plywood. O. L. Johansen and Dr. Nat. V. B. Kumar.

New channels of employment for wood fiber board, as a substitute for wood and other wood products, or due to its certain improved and more standard properties over ordinary wood, as an additional material of construction, are constantly being explored.

In order to study and also enlarge their potentialities for various technical and allied fields, it is imperative to investgate the fundamental properties of the fiber boards. Out of their many basic properties, one of the least studied is that of diffusion of liquids through various types of boards. Many technological processes utilizing wood fiber board may necessitate at some stage either penetration or prevention of leakage of various types of solutions through it. No comprehensive experimental study about diffusion through fiber board or plywood appears to have been made as yet.

In the first part of the work presented in this paper, the diffusing properties of some common varieties of hardboards and plywood, for sodium cloride, is discussed; in the second part, diffusion of common salt through some plastic treated fiber boards is described.

Results: The diffusion constants for the materials studied are given in Table 1 and the quantity of the salt diffusing (Volume of $AgNO_3$) as a function of time are plotted in Figs. 2 and 3. The diffusing areas, volumes of the jars, etc., were constant for almost all cases so that the volume of titre gave a comparative idea of the impedance of the membrane for NaC1 directly. In those cases where the curves are starting away from the origin on the x- axis, the diffusion was first detected on that particular day.

These results show that the diffusion of common salt, as expected, varies with the quality of the board e.g. an unsized or Holzrit-sized (blood albumin and sulphite waste liquor) board having σdB 450 kg./cm² possesses higher diffusion constants than a good sized or unsized board with σdB 450 kg./cm². Better sizing of the board and closer contact between the fibres would increase the bending strength and also the impedance of the boards for the diffusing substance. Sizing with ordinary paraffin wax (1%) decreased the diffusion constants considerably; although sizing with paraffin is known to be detrimental for the strength properties, it reduces the diffusion possibly due to its non-polar and hydrophobic character. An additional coat of phenol formadehyde (low viscosity) over paraffin-sized board decreased the diffusion constant only slightly. Phenol formaldehyde is a polar film containing OH-groups which possess action exchange capacity and therefore its impedance for NaC1 is not very great, especially when a single coat is given to the board.

Table 1.—DIFFUSION CONSTANTS CM²/DAY AT ROOM TEMPERATURE

Material		Diffusion Constants
Untreated Board	(σ_{dB} — 400 kg/cm²)	1.71 x 10—³
—»—	(» — 450 »)	2.67 x 10—³
Holzrit Sized	(σ_{dB} — 400 »)	1.71 x 10—³
—»—	(» — 450 »)	2.40 x 10—³
Paraffin »		1.15 x 10—⁴
Wood		4.56 x 10—⁵
Plywood Beech		2.67 x 10—⁴
» Birch		2.52 x 10—⁵
» Pine		1.31 x 10—⁴

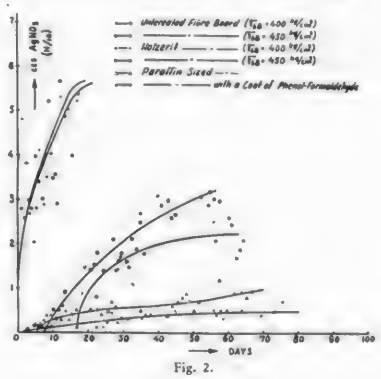

Fig. 2.

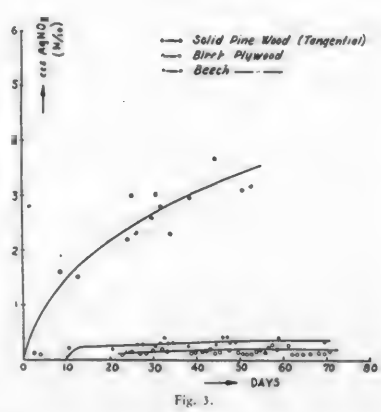

Fig. 3.

Diffusion behavior of plywood seems to depend upon the species. Pine and birch specimens allow smaller quantities of the salt to diffuse through them than beech; the beech sample used had diffusion almost equal to that of a good wallboard. It may be noted, however, that diffusion through plywood may show more variations within species than through fiber board, since the diffusion of a liquid in glued wood can depend upon a large number of factors, e.g. density of species, type of glue used for bonding the veneers, portion from where the veneers have been taken etc.

The diffusion of salt through pine in the tangential direction, as usual, was very small. Here also one can expect large variations within species.

The above results show that the diffusion through fiber board—both sized with Holzrit and unsized—is many times more than through wood across the grain and also to some extent through plywood. In order to increase the resistance of fiber boards against diffusion of common salt, they should either be given a surface coating (with a metallic paint or a high polymeric material) or a non-polar and stable sizing agent should be employed. For selecting the most suitable material for this purpose, one requires a fundamental study about the diffusion of sodium chloride through organic membranes. This will be the subject of the second part of this publication.
(Ed. Note: Part 2 of this report will appear in the December FOREST PRODUCTS JOURNAL.)

Norsk Skogindustri. V. 9, No. 1, January 1955. Variations in Thickness of Hardboards. Av Kjell Helge og Knut Krogstad. (In Norwegian)

It is a well known fact that hard wallboard is generally more or less uneven in thickness. Measurements and experiments show that this unevenness is caused by variations in the mechanical conditions in the hot press. Thus, varying thickness of the transport plates as well as the press platens, or uneven yielding in the press itself will be reflected in the board, and this may cause variations in the quality of the hard board.

Wood Industry, V. 10, No. 8, 1955. Published monthly in Japanese by the Wood Technological Association of Japan, % Government Forest Experiment Station, Meguro, Tokyo, Japan.

Effects of raw chip dimension on the physical and mechanical properties of chipboard. Kakuichi Kitahara and Kazuo Kasagi.

When the dimension of raw chip is changed, the physical and mechanical properties of chipboard are changed with it. In this case, binding material, for example urea resin, per unit surface of chip is changed if the binding material (per cent) is constant to the weight of whole raw chips in oven dry, and the factors affecting them should be two in constant pressure. One is the quantity of binding material per unit surface of chips and the other is the dimension of chip itself.

The physical and mechanical properties of chipboard depend upon both the binding material per unit surface of chips and the intertwining among chips. When the former is constant as in this experiment, the latter is easily raised in smaller chips.

World Forest Resources — published by FAO of the United Nations in March, 1955, describes the results of an inventory undertaken in 1953 by the Forestry Division of FAO. Providing the most comprehensive picture of the extent of the world's forests so far published, it confirms that the world's forests are theoretically capable of furnishing a plentiful flow of forest products for a world population much higher than that of today. Of 3,840 million hectares (FAO common denominator, a hectare being equal to 0.4047 of an acre) of woodlands, less than a third today is utilized. And of the immense unexploited reserves of standing timber in the world today, over 680 million hectares are accessible at the present time.

A fundamental question is whether natural losses and fellings exceed the rate at which wood is being produced. Are the forests being overcut? As a rough estimate it can be said that in the world's 600 million hectares of exploited coniferous forests, growth and drain are in balance—at around 1,100 million cubic metres with bark. On the other hand, in the 540 million hectares of exploited broadleaved forests, gross increment is reckoned at 1,300 million cubic metres, of which perhaps three-quarters is drained off by fellings or natural losses. This under-exploitation derives largely from the fact that many of the species growing in the tropical and sub-tropical forests are not today marketed, and but a fraction of the non-commercial species utilized as fuel.

Finally, over vast areas of the world, forest management has not attained the stage of sustained yield. This inventory, while it tells us far more than has been known before, still represents but a progress report. Further advances will depend on wider adoption of organized forest services and statistical machinery.

FAO Equipment Notes

Note E. 5.55, Portable treating plant for fence posts.

Methods of fence-post treatment include soaking in hot and cold baths, prolonged cold soaking, and low-pressure soaking. The latter is a variation of the cold soak with the process greatly accelerated by the use of pressures up to 10 lb. per sq. in. (7 kg. per cm²). To demonstrate these last two methods, a portable plant suitable for treating up to 50 round posts at a time has been designed and constructed.

Specifications: A cylinder 3 ft. in diameter and 6 ft. long is mounted horizontally on a trailer chassis. It is designed for pressure up to 10 lb. per sq. in., and is fitted with a quick-sealing door at one end. Directly above is a smaller tank which holds enough preservative to fill the cylinder when the full quantity of posts is in place.

In low pressure treatments, the need for a motor-driven pump for applying the pressure is avoided by the installation of a 44-gal. drum high up on a windmill stand or in a tree. A ½-in. plastic hose is provided to connect this drum to the cylinder.

With a 20-ft. head, satisfactory treatment can be given to the sapwood of most eucalypts in 24 hours or less, for the greater part of which time the plant can be left unattended. Rounds of *pinus radiata* (which make excellent posts) may be treated by soaking without pressure, but given low pressures, treatment can be reduced to a few hours. For information, write to: Commonwealth Scientific and Industrial Research Organization, P. O. Box 18, South Melbourne S.C.4., Australia.

Note D. 5.55, The Glomera briquettor.

This is a high pressure briquetting process without binder which uses not only wood waste, sawdust and bark, but also peat, lignite, coal, cotton stalks, sugar cane bagasse, etc.

Wood waste shavings and sawdust of coarse size, or any other materials used, must be ground to a size ranging between 10–20 mesh. As the moisture content of wood waste should range from 10 to 15 percent a special flash dryer has been developed. Clamps reduce the material to about a third of its initial volume just before the piston moves forward. This system of alternating over and under pressure, repeated more than 7,200 times per hour, guarantees a steady flow of material.

Manufacturer: Pawert Ltd., Zwingerstrasse 26, Basle, Switzerland.

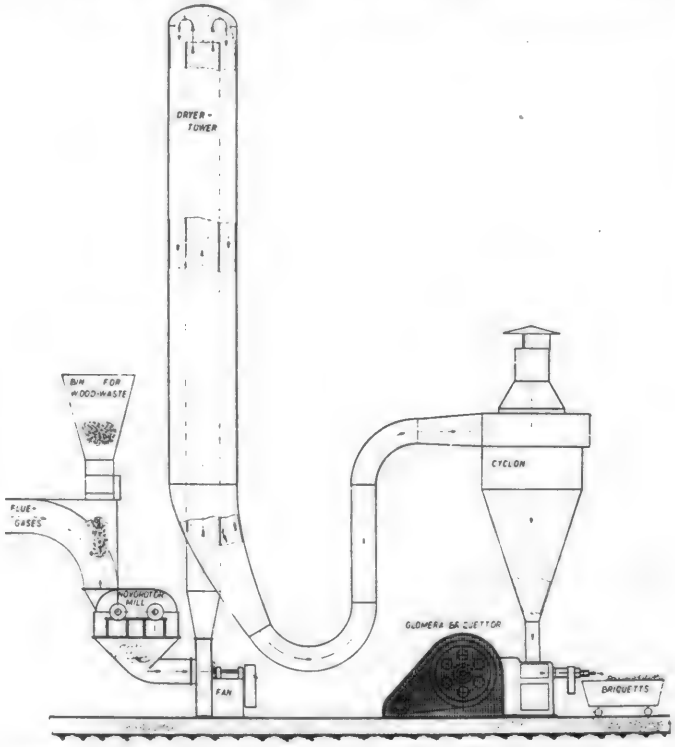

Diagram of the complete apparatus, showing the percussion mill, flash dryer, and briquettor (shaded).

Abstracts From Current World Literature

Veneer and Plywood

Curry, W. T. The strength properties of plywood. Part 2. Effect of the geometry of construction. *Bull For. Prod. Res., Lond.* No. 33, 1954.

[Cf. *For. Abstr.* 15 (No. 2923).] Equations are presented for calculating bending, tension, compression and shear strengths of any plywood construction, using basic data on 3/16-in. plywood. Results obtained with the equations have been checked against test figures for plywood of various thicknesses from *Aucoumea klaineana,* and reasonably close agreement was found. Agreement might not be so close for other species, but it is believed that the methods are suitable for general application and that tabulated basic strength values given for some 27 species can be used for estimating the strength of plywood made from one or more species of wood. An example is given of the use of the data in determining strength of a ½-in. plywood of 1·2·2·2·1 construction, with face and back of *Mimusops heckelii* and core and crossbands of *Gossweilerodendron balsamiferum.* [For. Abs. V. 16, No. 3]

Wood Preservation

Mateus, T. J.E. Evaluation fo wood preservatives by a new method based on measurements of deflection. *Publicaçao, Laboratório Nacional de Engenharia Civil, Lisboa* No. 48, 1954.

Wood specimens exposed to attack by fungi *(Polystictus versicolor, Poria vaporaria* and *Coniophora cerebella)* showed marked increases with time in deflection under a constant static load, while deflection values for undecayed controls remained comparatively constant. A method is described of estimating variations in amount of deflection of test specimens subjected to a load of known magnitude as a measure of the amount of decay present and its progress. A comparison with results from the more usual method of measuring decay by loss of weight demonstrates the greater sensitivity of the deflection method. By the deflection test also the progress of fungus attack in the specimen can be followed and information about the effectiveness of preservatives can be speedily collected. [For. Abs. V. 16, No. 2]

Findlay, W. P. K., and Savory, J. G. Moderfaule. Soft rot. Wood decay caused by lower fungi. *Holz Roh- u. Werkstoff* 12 (8), 1954.

Laboratory tests have shown the soft rot occurring in cooling towers to be caused by the following fungi: *Chaetomium* (in particular *C. globosum*), *Trichurus terrophilus, Bispora effusa,* and some *Stysanus, Stemphylium* and *Coniothyrium* species. It has been found that for *C. globosum,* the attack (measured as weight loss after 6 weeks) increased as the concentration of the nutrient salt solution increased. The soft rot is characterized by penetration of hyphae into the secondary wall, but not into the middle lamella, decay being particularly significant in the thick-walled late-wood elements. Cu-containing chemicals afford some protection. [For. Abs. V. 16, No. 2]

Properties of Wood

Wardrop, A. B. The fine structure of the conifer tracheid. *Holzforschung, Berlin* 8 (1), 1954 (12–29).

Reviews some aspects of the chemical and physical nature of the cell wall in conifer tracheids. This includes a discussion of the chemical constituents and the nature of their physical aggregation with reference to the significance of the microfibrils revealed by electron microscopy and the micelles deduced from X-ray studies. New data on the degree of lateral order in different celluloses are presented. Evidence that the microfibrils represent supermicellar units is considered inconclusive because of the established variation in the size of microfibrils in different celluloses and the variation in lateral order revealed by X-ray examination of similar material. The cell-wall organization of the conifer tracheid is discussed with reference to the orientation of the micellar strands in the primary wall and the 3 layers of the secondary wall as revealed by the techniques of optical microscopy, polarization optics, X-ray diffraction and electron microscopy. Evidence for the existence of a crossed fibrillar structure in the several layers of the secondary wall is presented. It is considered possible that such a structure is present to the outer layer of the secondary wall, but this is improbable in the middle layer. The swelling behaviour of delignified conifer tracheids before and after acid hydrolysis is described and the possible influence of orientation of the micellar strands in the different layers of the secondary cell wall upon this process is discussed. The suggestion that the transverse fissures arising upon swelling of acid-hydrolysed fibres represent intrinsic transversely oriented structures in the cell wall is rejected. It is suggested that these fissures arise in the region of cell-wall deformities which are susceptible to acid hydrolysis. Electron micrographs give no evidence of any pre-existent transverse structures. The relation of these studies to chemical evidence for the existence of acid-susceptible linkages in cellulose molecules is indicated briefly. [For. Abs. V. 16, No. 1]

Chalk, L. The influence of gross anatomy on the shrinkage of wood. [*Pap.*] *8th int. bot. Congr., Paris, Sect. 13 A* 1954.

The average ratio of tangential to radial shrinkage is approximately the same in both hardwoods and softwoods, but this result may be achieved in different ways in these groups. The cause of differential shrinkage has long been regarded as lying in the secondary wall, and this appears to explain the greater shrinkage of dense wood and of the late wood of conifers. Others have sought the cause in the 'middle lamella', using this to explain the difference between radial and tangential shrinkage in conifers and the shrinkage of large rays in hardwoods. The relative importance of rays appears to depend on the proportion of the tissues which they occupy and possibly on cell size and shape. It is suggested that the question of which factor predominates in any particular wood depends on the gross anatomy of the wood. [For. Abs. V. 16, No. 1]

Wilson, J. W. Fibre technology—I. Fibre length mensuration: a comparative history and new method. II. A critical survey of laboratory wood maceration techniques. *Pulp Paper Mag. Can.* 55 (5;7), 1954 (84–91; 127–9). 149 and 55 refs. (*Res. Pap. Fac. For. Univ. B.C.* Nos. 4, 7.)

I. The new method consists of microscopic projection of the fibre on to a suitably graduated circular target. It is known as the 'graduated bull's eye target method'.

II. Existing methods, none completely satisfactory, are discussed. Research to develop new methods has been started at the University of British Columbia. Active oxygen (peroxygen) chemicals, both inorganic and organic, offer possibilities. [For. Abs. V. 16, No. 1]

Seasoning

Sergovskii, P. S. On the mechanism of the movement of moisture in wood during convection-type drying. *Derev. lesohim. Prom.* 3 (4), 1954 (3–8). From *abstr.* in *Holz-Zbl.* 80 (111), 1954 (1294).

In accordance with the view accepted at present by Soviet scientists and technologists, illustrated by graphs and tables, (1) the rate of moisture movement at right angles to the grain varies as the moisture gradient and the coefficient of moisture conductivity, when the moisture content (m.c.) of wood is below fibre-saturation point (f.s.p.), whereas (2) with the m.c. > f.s.p., the rate of moisture movement is not determined by the moisture gradient. When initial m.c. > f.s.p., the wood surface

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The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham, Royal, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains about 1,200 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

quickly attains f.s.p. owing to the effect of air; a difference of capillary pressure is thus produced between the outermost and next adjacent wood layers. After some time, three zones are formed: (1) a diffusion zone, with m.c. $<$ f.s.p., where the rate of moisture movement is proportional to the moisture gradient; (2) a zone in which the free moisture evaporates, this moisture increasing towards the middle of the wood, and its mean value being $>$ f.s.p., and (3) a capillary zone where m.c. $>$ f.s.p. [For. Abs. V. 16, No. 2]

Wood Chemistry

Lange, P. W. The distribution of lignin in the cell wall of normal and reaction wood from Spruce and a few hardwoods. *Svensk Papperstidn.* 57 (15), 1954 (525–35). (Part IX of The distribution of the components in the plant cell wall.)

Lignin distribution was studied by microspectrographic methods in the ultraviolet range. Results, shown in transmission curves and photomicrographs, indicate that lignin is mainly deposited in the compound middle lamella. In Spruce, the concentration round the lumen is 15–25% of that in the middle lamella. For the hardwoods examined (Ash, Aspen, Beech, Birch and Elm) the lignin, concentration in the secondary cell wall was less than that of Spruce. The secondary cell walls of compression wood of Spruce and tension wood of Beech contained very little lignin. [For. Abs. V. 16, No. 1]

Zimakov, P. V., and Pokrovskii, V. A. A peculiarity in the interaction between the vapours of ethylene oxide and wood. *Z. prikl. Him.* 27 (3), 1954 (346–8).

The authors found that pieces of wood not impregnated previously with an alkali, when kept for a long time in C_2H_4O vapour, sometimes change their colour (to brown or black) but neither change their dimensions nor bind large quantities of C_2H_4O. When impregnated with alkali, the bulk of the wood reacts with the vapour which diffuses slowly into it. Products of this reaction seem to exert pressure from inside on the structural elements of the wood; these markedly increase in volume, the wood swelling and becoming loose-structured. After several weeks in C_2H_4O vapour, wood swells uniformly in all directions and presents the appearance of untreated wood observed through a magnifier. [For. Abs. V. 16, No. 1]

Sarkov, V. I., Efimov, V. A. and Muromceva, V. S. Effect of growth conditions on the chemical composition of Spruce wood. *Z. prikl. Him.* 27 (1), 1954 (92–6).

The authors found that, irrespective of the conditions of growth, the pentosan content decreases from pith to periphery and from top to base, whereas that of methylpentosans increases from pith to periphery and from base to top. The chemical composition of Spruce wood depends, in the first place, on the age of the growth rings, and not on their width. [For. Abs. V. 16, No. 1]

Composition Board

Kollmann, F. The present status of technology in chipboard manufacture. *Holz Roh- u. Werkstoff* 12 (4), 1954 (117–34).

Tabulates the properties of 13 German-made chipboards and gives an illustrated description of machines for chipping, chip drying, chip screening, mixing of chips with the binder, dosing, moulding and pressing, as shown at the 1954 Hanover Fair. [For. Abs. V. 16, No. 1]

Dosoudil, A. Testing methods for wood chipboards and fibreboards. A brief survey with suggested heads of discussion. *Holz Roh- u. Werkstoff* 12 (2), 1954 (55–64).

Discusses the testing methods recommended in different countries for the determination of: water uptake and swelling, permeability to water, form stability, bending strength, tensile strength, compression strength, shear strength, strength of bolted joints, hardness, impact strength, puncture, durability, wear, surface quality, heat conductivity, acoustic properties, combustibility, and resistance to fungi and insects. [For. Abs. V. 16, No. 2]

Barking

Barker review. *Lumberm.* 81 (9), 1954.

Discusses the selection of barkers, lists different types (with details of design and advantages and manufacturers), and discusses the barkers (including two mounted on barges) used by various N. American mills. [F.D.C. Tech. Bul. V. 4, No. 24]

Bott, Rudolf. Interesting experiments in wood barking. *Das Papier* 8, (23/24) 564–5. (Dec. 1954).

A brief reference is made to the rebuilt hardboard plant of the Norddeutsche Homogenholz GmbH at Triangel (which was completely destroyed by fire in 1952, *cf.* B.I.P.C. 23: 706); it utilizes principally pine, but also small quantities of birch, poplar, and alder thinnings, generally delivered in completely unbarked condition. A special barking drum has been installed for the complete removal of all bark required by the dry process used. The effluent from the barking installation is drained into a canal filled with birch twigs which discharges into a lagoon. The retained bark is either used as fuel or for filling adjacent peat cuttings. [Bul. Pap. Chem. V. 25, No. 7]

Economics

Wheeler, P. R. Forest resource changes found in Alabama, Arkansas, Louisiana, and Mississippi. *Southern Pulp Paper Mfr.* 18 (3) 1955.

The resurvey of commercial forest area in the four southern states showed a total of 66 million acres, a 3% increase since the original survey in 1932–1936. There were some interior shifts in land use, most notable of which was a 12% decrease in forest in the Mississippi River Delta because of land clearing for agriculture and a complementary increase in forest in the uplands. The upland hardwood forest type has increased largely at the expense of the pine types. Total growing stock has decreased, the softwood volume about 6% within the 15-20-year period, whereas the hardwoods have about held their own. A table is presented showing the total forest area, softwood and hardwood sawtimber and growing stock, and the percentage of increase or decrease between the two surveys. [Bul. Pap. Chem. V. 25, No. 8]

Beggs, A. Kenneth. The business outlook in forestry. *Pulp Paper Mag. Can.* 56 (3) 1955.

The findings of the Stanford Research Institute report on America's demand for wood and wood products (covered in the previous reference) which relate to future markets for lumber and pulp and paper are covered. [Bul. Pap. Chem. V. 25, No. 8]

Zellerbach, J. D. Our stake in world trade. *Paper Trade J.* 139 (9) 1955.

The author urges men in the pulp and paper industry to change from an attitude of protection under tariffs and controls on imported paper and paper products to a growing support of free world trade, which will serve the best interests of the industry and the United States economy. [Bul. Pap. Chem. V. 25, No. 7]

Finishes

Organic finishing handbook 1954. Finishing Publications Inc., U. S. A., 1954.

This handbook is divided into five parts. The first deals with the raw materials used in surface coatings, the second part is devoted to the methods of application, the third to the types of finish which are available, the fourth to methods of test and the last is an appendix. Although some of the information is only applicable to metal surfaces the majority will be of interest to manufacturers of wooden furniture.

There are three sections which deal with the faults arising during finishing due to the material used or the technique of application. The prevention of lacquer blush is discussed in some detail.

The section on spraying includes notes on air compressors, pipe lines, air transformers and a table of the drop in air pressure from the compressor to the gun.

A concise article on dipping gives the advantages and disadvantages of this system and some notes on the equipment required. The section on drying and baking includes notes on convection ovens and on radiant heating equipment. A series of eight diagrams of ovens for baking finishing materials includes batch-type ovens and those suitable for floor and overhead conveyors. [F.D.C. Tech. Bul. V. 4, No. 24]

Residue Utilization

Brown Co. explores wastewood chippers and bark removal methods. *Paper Trade J.* 139 (19): 110–12 (May 9, 1955).

Three machines, the Carthage portable disk chipper, the Impco Equi-Flow chipper, and the Bauer Chip Abrader, are emphasized in this description of machinery tested in research on the increased utilization of both soft- and hardwood slabs, edgings, trims, and slash as a source of pulp. [Bul. Pap. Chem. V. 25, No. 10]

Anderson, Arthur B. Recovery and utilization of tree extractives. *Econ. Botany* 9 (2): 108–40 (April–June, 1955).

Some of the more important practices in the recovery and use of tree extractives are described; no complete review of the subject is intended. Pine tree resins and turpentine (rosin and turpentine from oleoresin, wood rosin and turpentine, and sulfate turpentine and tall oil), tannins and dyes, volatile oils, tree exudates, miscellaneous (waxes, tung oil, and quinine), and some recent developments (Douglas-fir bark extractives, rosin from ponderosa pine stumps, pinitol, conidendrin, and extractives from British Guiana hardwoods) are considered. [Bul. Pap. Chem. V. 25, No. 10]

Forest Genetics

Johnsson, Helge. The activities of the Association of Forest Tree Breeding; a review of results obtained to date and current research. *Svensk Papperstidn.* 58 (5): 165–76 (March 15, 1955).

The author summarizes the results of forest-genetics studies with pine, spruce, larch, birch, aspen, alder, oak, beech, ash, and elm carried out in the three experimental stations of the association at Ekebo in southern, Brunsberg in central, and Sundmo in northern Sweden. A bibliography of the publications issued during the period 1938–1954 is appended. [Bul. Pap. Chem. V. 25, No. 9]

Wood Drying Committee Newsletter

Steam: Its Properties and Uses in Kiln Drying[1]

WITH ABOUT 99 PER CENT of the operating kilns of today using steam as a medium of heat, it is essential that kiln operators have a working knowledge of steam and its practical application in the operation of lumber kilns.

Temperatures (or temperature settings) are related to sensible heat, but are not synonymous with it, since sensible heat is expressed in British thermal units. Latent heat is likewise expressed in British thermal units and is the heat required to change water at a given temperature into steam at the same temperature. Conversely, the latent heat is released when steam at a given temperature is condensed to water at the same temperature. Changes in sensible heat are detectable with a thermometer and depend upon the density, specific heat, and change in temperature. Latent heat basically means "hidden" heat, since it cannot be detected with a thermometer. A boiler horsepower is equivalent to the evaporation of 34.5 pounds of water per hour from a temperature of 212° F. to dry saturated steam at the same temperature. The energy required to evaporate this quantity of water is 33,479 British thermal units per hour.

The latent heat of the steam, plus a part of the sensible heat of the condensed steam in the heating coils in a kiln, provide the heat required for drying the lumber.

The changing of 1 pound of steam to 1 pound of water releases quantities of latent heat that decrease as the pressure increases. Thus, at zero, 10, and 100 pounds per square inch gage, the approximate quantities of heat released are 970, 953, and 881 British thermal units.

A drop of 1° F. in 1 pound of water releases 1 British thermal unit. The corresponding drop in temperature of 1 pound of water at 338° F. and 100 pounds per square inch gage to 212° F. would release only 116 British thermal units. On the other hand, the condensation of 1 pound of steam to water would release 881 British thermal units. Hence, the ratio of the latent heat of the steam to the sensible heat of the water is 881/116, or 7.6.

When a pound of steam at a pressure of 10 pounds per square inch gage is condensed to water at the same pressure, 953 British thermal units are released. Under the same conditions, the drop in temperature of the water from 239° to 212° F. would release only 27 British thermal units (239°–212° F.) Hence, the ratio of the latent heat of the steam to the sensible heat of the water is 953/27 or 35.3.

The following table gives a comparison of the various properties of steam, such as pressures, temperatures, total heat, and volume available that kiln operators must understand.

From this table, it is seen that adding 970 heat units or British thermal units to 1 pound of water at 212° does not change the temperature or pressure, but changed the liquid to vapor and made a tremendous volume change. Adding additional British thermal units to this 1 pound steam that is now in vapor state, and increasing the pressure to 10 pounds, increases the temperature but decreases the volume. This again holds true when adding more British thermal units and increasing the pressure to 100 pounds pressure.

Knowing that almost all kiln schedules are operated at 200° F. or less, it can be seen from the foregoing table that steam at zero pound pressure would theoretically have enough heat for obtaining the desired heat within the kiln. Steam at higher pressures is commonly used, however, to increase the rate of flow and to reduce the differences in temperature throughout the length of the kiln.

Many everyday operational kiln problems are direct results from improper handling of steam.

A fundamental knowledge of steam and its properties is a long step in the practical and economical operation of steam heated dry kilns.

Material	Pressure Lb. per sq. in. gage	Temperature ° F.	Total heat B.t.u. per lb.	Volume Cu. ft. per lb.
Water	0	212	180.1	0.02 (.01672)
Steam	0	212	1150.4	26.80
Steam	10	239	1160.4	16.49
Steam	100	338	1189.6	3.89

[1] Talk presented by Franklin W. Cook, Moore Dry Kiln Co., at meeting of Southern California Lumber Seasoning Assoc. Oct. 6, 1953.

BOOK REVIEW

Forestry and Related Research in North America[1]

FRANK H. KAUFERT and WILLIAM H. CUMMINGS

$200,000,000 in annual expenditures for forestry and related research in North America is the goal suggested for attainment by 1978 in a recently published study conducted by the Society of American Foresters, under the direction of a steering committee representing jointly the Society and the National Research Council Division of Biology and Agriculture. The study was financed by The Rockefeller Foundation. Expenditures in 1953 amounted to $45,400,000 by all agencies. This 4.4-fold increase calls for industrial and private organizations to assume a position of leadership, not only in the conduct of research but in stimulating, guiding, and assisting in the correlation of all research efforts.

The report suggests that federal expenditures in the total forestry research picture decrease percentagewise from the present 21 per cent of the total to around 15 per cent, with the schools, other public agencies, and private research picking up the bulk of the 1978 check. Timber production research, $9,800,000 in 1953 should reach $55,000,000 annually in 25 years; forest products and utilization research should rise from $31,000,000 to $125,000,000; related management (wildlife, range, watershed and recreation) should increase from $4,600,000 to $20,000,000.

The authors point out that the present research investment of $45,400,000 is less than that made by one large chemical company. The 1978 goal of $200,000,000 is considerably less than the present combined research investment of four of the largest corporations in the United States. They also point out that the present investment for forest products and utilization research is 0.25 per cent of the timber product value, while most industries competitive with timber products are investing at least 1 per cent, and many are investing more, to insure present, and develop new, markets.

—A. G. HALL
What's Happening in Forestry

[1] Published by Society of American Foresters, Mills Building, Washington 6, D. C. $5.

WILLIAM B. GREELEY, one of America's forestry leaders. He helped inspire *voluntary* conservation by farmers, timber owners and the public . . . including Keep America Green and More Trees for America movements. U. S. Chief Forester, 1920-28; manager West Coast Lumbermen's Assn., 1928-45; now Board Chairman, American Forest Products Industries.

pioneering the idea of voluntary forest conservation...

Wood is used in more than 4,000 products ...from homes to paper, rayon, cellophane and tissues. There can always be wood for such uses from privately owned tree farms.

"True forest conservation can be accomplished more by the voluntary cooperation of individuals, rather than by law." Guided by this practical philosophy, Col. W. B. Greeley and many other thoughtful men of forestry have inspired exceptional progress in perpetuation of the nation's wood supply. It is the American way. It reflects more confidence in education and persuasion than in arbitrary authority. This faith has been rewarded by growth of the tree farm movement throughout the nation.

Today, about 6,100 industrial and farm woodland owners are *voluntarily* growing timber as a crop on 34 million acres certified as tree farms. And *voluntary* cooperation by the public, industrial foresters and government forest agencies is reducing forest fire losses, year by year.

Timber harvest and new timber growth are now practically in balance. Commercial forestlands are providing a permanent supply of wood for lumber, paper and chemical products. Weyerhaeuser Timber Company is among those who voluntarily manage forestlands for perpetual wood production. The full story of modern tree farming is interesting. *For more complete information, write us at Box A, Tacoma, Washington.*

Weyerhaeuser Timber Company

National Meeting

(Continued from page 29-A)

on the shores of beautiful Hood Canal. Here an estimated 500 registrants and their families were guest of 66 wood industry suppliers, including:

American Cyanamid Co., Seattle, Wash.
American Defibrator Inc., New York, N. Y.
American–Marietta Co., Adhesive, Resin and Chemical Div., Seattle, Wash.
American Manufacturing Co., Inc., Tacoma, Wash.
Automatic Sprinkler Corp. of America, Seattle, Wash.
Borden Co., Chemical Div., Seattle, Wash.
Bramco, Inc., New York, N. Y.
Burke Millwork Co., Seattle, Wash.
Carborundum Co., Niagara Falls, N. Y.
Chicago Mill and Lumber Co., Tallulah, La.
Clark Equipment Co., Battle Creek, Mich.
Crown–Zellerbach Corp., Seattle, Wash.
Curt G. Joa, Inc., Sheboygan Falls, Wis.
Douglas Fir Plywood Assoc., Tacoma, Wash.
The Dow Chemical Co., Midland, Mich.
Elliott Bay Mill Co., Seattle, Wash.
E. V. Prentice Co., Portland, Ore.
Fjellman–American Inc., Joliet, Ill.
Forest Interiors Manufacturing Co., Inc., Seattle, Wash.
Foss Launch and Tug Co., Tacoma, Wash.
Gerlinger Carrier Co., Dallas, Ore.
Henry Disston and Sons, Inc., Seattle, Wash.
Hitchcock Publishing Co., Wheaton, Ill.
Industrial Woodworking, Greenwich, Conn.
Kennametal, Latrobe, Pa.
Koppers Company, Inc., Pittsburgh, Pa.
The Long–Bell Lumber Co., Longview, Wash.
Mann–Russell Electronics, Tacoma, Wash.
Masonite Corp., Chicago, Ill.

Chef Chet Ullin, Pacific Northwest Potlatch authority, gives large fillets of Chinook salmon a turn over the fire in preparation for the feast. Potlatch guests, 450 strong, consumed more than 600 pounds of salmon.

Indian dancers in native surroundings provided a taste of the colorful Northwest as they interpreted various tribal dances.

Mattison Machine Works, Rockford, Ill.
McManama and Co., Seattle, Wash.
Merco Industrial Equipment, Inc., Seattle, Wash.
Mereen–Johnson Machine Co., Minneapolis, Minn.
Merritt–Solem Div., Solem Machine Co., Lockport, N. Y.
Milwaukee Boom Co., Tacoma, Wash.
Monsanto Chemical Co., Seattle, Wash.
Moore Dry Kiln Co., Jacksonville, Fla.
National Casein, Chicago, Ill. and Riverton, N. J.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Nicholson Manufacturing Co., Inc., Seattle, Wash.
Oliver Machinery Co., Grand Rapids, Mich.
Oronite Chemical Co., San Francisco, Calif.
The Pacific Lumber Co., San Francisco, Calif.
Philadelphia Quartz Company of California, Berkeley, Calif.
Production Management Engineering Associates, Inc., Portland Ore.
Protection Products Manufacturing Co., Kalamazoo, Mich.
The Quaker Oats Company, Chemicals Dept., Portland, Ore.
Reichhold Chemicals, Inc., Seattle, Wash.
Rockwell Manufacturing Co., Delta Power Tool Div., Pittsburgh, Pa.
Simonds Saw and Steel Co., Portland, Ore.
Star Machinery Co., Seattle, Wash.
Stetson–Ross Machine Co., Seattle, Wash.
Sumner Iron Works, Everett, Wash.
Tallman Machinery Co., Seattle, Wash.
Timber Structures, Inc., Portland, Ore.
Titan Chain Saws, Inc., Seattle, Wash.
United States Plywood Corp., Seattle, Wash.
Van Waters and Rogers, Inc., Seattle, Wash. and Portland, Ore.
Washington Machinery Co., Seattle, Wash.
West Coast Lumbermen's Assoc., Portland, Ore.

SESSION IV—SMOG CONTROL, ELECTRIC DRIVES AND WOOD PRESERVATION.

SESSION V—PACKAGING.

SESSION VI—CHEMICAL UTILIZATION

SESSION VII—GLUES AND GLUING

West Coast Wood Preserving Co., Seattle, Wash.
Weyerhaeuser Timber Co., Tacoma, Wash.
Wienker Machinery Co., Seattle, Wash.
Williams Patent Crusher and Pulverizer Co., Inc., St. Louis, Mo.
Yates–American Machine Co., Beloit, Wis.

The Potlach will be an FPRS event never to be forgotten by those who attended. It started with a bus drive to the ferry station at the harbor of Seattle and then by ferry to Bremerton, site of one of our largest U. S. Navy shipyards. At Bremerton we were again picked up by special busses and conducted on a tour of the shipyards. It was a stirring sight to see the famous "mothball" fleet and inspiring to recall, as we passed each of the famous carriers, battleships, and destroyers, their past glories—Wake Island . . . Midway . . . Coral Sea . . . culminating in the famous surrender off the Coast of Japan on the "Mighty Mo".

Leaving Bremerton, we continued along the peninsula to the Park. Awaiting us on this brisk, cool evening were large tables of appetizers—clam nectar, buttered clams, and kippered salmon. These were followed by the picnic style, full course, out-of-doors dinner of fresh, barbecued Chinook Salmon. Following the feast, a program of authentic native Indian dances portraying Northwest and Plains tribes took place in a clearing surrounded by magnificent firs. The National Meeting Committee billed the Potlatch as "one of the best times of your life"—truer words were never spoken.

AUTOMATIC PROCESSING of forest products into lumber and pulp were observed on all-day field trip to Weyerhaeuser Timber Co. lumber division (top) and kraft mill (below.) Group also visited pulp and paper division of Simpson Logging Co.

All-Day Field Trip

The final day of the Ninth National Meeting was devoted to an all-day field trip to Everett, Washington, where operations of Weyerhaeuser Timber and Simpson Logging Companies were viewed. Residue utilization in action was witnessed by some 100 registrants. At Weyerhaeuser Timber Co. lumber division, they saw automatic equipment processing logs from the pond to the box car. The mill utilizes a large proportion of the waste materials resulting from the 30 box cars of lumber produced daily. Bark is used as fuel, chips from slabs and edgings are conveyed to the nearby kraft mill, and sawdust is converted into 160 tons of Pres-to-logs daily.

At the kraft mill, chips are used in producing 250 tons of pulp per day. The last stop was the Everett Pulp and Paper Division, Simpson Logging Co., where final conversion of kraft pulp to school and commercial stationery items was observed.

Employment Service in High Gear

For the second straight year, FPRS' informal employment service for people seeking positions and for employers seeking personnel was under the able direction of Prof. Newell A. Norton, Pennsylvania State University. A meeting of the Employment Committee (see page 88–A) was held on Monday evening, June 20; the Employment Placement Service was active from 2:00 to 5:00 P.M. on Tuesday and from 9:00 A.M. to 12:00 NOON on Wednesday and Thursday.

Record Ladies' Program

One record set at the National Meeting was the attendance at the Ladies' Program. The final tabulation showed 109 ladies present from every region of the Society. The ladies were welcomed at an afternoon tea on Tuesday by Mrs. Earl McCarthy, Seattle, Chairman of the Ladies' Program, and Mrs. Lester J. Carr, Sacramento, Calif., wife of the President. The tea was held at the Hathaway House, a colorful shop featuring many native Northwest arts.

On Wednesday the ladies were escorted on a scenic tour of Seattle, stopping for lunch at the picturesque

SESSION VIII—EDUCATION

SESSION X—WOOD MACHINING

STOP BURNING DOLLARS

. . . start selling Chips

Produce Quality–
SPECIFICATION SIZE CHIPS
From • SLABS • EDGINGS
• ROUND WOOD or
VENEER CORES !

MURCO

HIGH-SPEED MULTI-KNIFE

WASTEWOOD CHIPPER

The most flexible, versatile chipper design now available to chip producers, providing quantity production of quality specification-size chips demanded by pulp producers . . . operating with a minimum of slivers, sawdust and chip rejects . . . economically priced . . . easy to maintain . . . few parts to replace . . . low maintenance cost. MURCO high speed multi-knife chipper can be used as a portable unit, mounted on skid or trailer for Diesel engine drive. MURCO design is a result of more than 30 years experience in the manufacture of pulpwood chippers . . . MURCO chippers built in 1923 are still performing efficiently.

3 SIZES

56" diameter 12 knife disc will process 8 to 10 units (200 cu. ft. per unit) per hour.
64" diameter 12 knife disc will process 12 to 14 units per hour.
72" diameter 12 knife disc will process 16 to 18 units per hour.

FEATURES • Heavy duty anti-friction bearings for disc and shaft. • Fabricated structural steel base with machined seats for spout and bearings. • Fabricated steel plate spout fitted with removable steel liners. • Rolled steel plate disc fitted with renewable wear plates. • Shaft forged from high strength steel. • Welded steel hood is furnished plain as illustrated, or as a blower housing when pneumatic chip conveying is desired. • Shaft extension arranged for direct coupling to motor, V-belt or flat belt drive.

WRITE WRITE for complete proposal telling us size of largest slab or edging, volume of wood to be processed per hour, choice of drive and whether chips will be pneumatically conveyed.

... D. J. MURRAY MANUFACTURING CO.

Manufacturers Since 1883 • WAUSAU, WISCONSIN

REPRESENTATIVES IN ALL PRINCIPAL CITIES

But why MEN over 45?

Our doctors still don't know *why,* but if you are a man over 45 you are six times as likely to develop lung cancer as a man of your age twenty years ago. They *do* know, however, that their chances of saving your life could be about *ten times* greater if they could only detect cancer long before you yourself notice any symptom. (Only 1 in every 20 lung cancers is being cured today, largely because most cases progress too far before detected.)

That's why we urge that you make a habit of having your chest X-rayed every six months, no matter how well you may *feel.* The alarming increase of lung cancer in men over 45 more than justifies such precautions. Far too many men die *needlessly!*

Our new film "The Warning Shadow" will tell you what every man should know about lung cancer. To find where and when you can see this film, and to get life-saving facts about other forms of cancer, phone the American Cancer Society office nearest you or simply write to "Cancer"—in care of your local Post Office.

American Cancer Society

SESSION XI—MARKETING

Norselander seafood restaurant. The tour encompassed Woodland Park, Queen Anne Hill, the University of Washington campus and arboretum, Lake Washington floating bridge and Green Lake. Wednesday evening the gay FPRS Party climaxed the social program for the ladies.

Thursday found the ladies engaged in the traditional quest for fashion, hearing a talk on "Co-ordinating Color to You", by Mrs. Wilbur Zundel. This was followed by the voyage to Bremerton and Twanoh State Park for the Potlatch in the evening.

1955 National Meeting Committees

While the success of a large National Meeting such as was held at Seattle is literally dependent on the "teamwork" of more than 100 authors and others who contribute to the technology of the meeting, a special vote of appreciation is always due the many hard-working arrangements committees who have spent so many hours in the preceding year to assure a smooth-running meeting. Here are the 1955 Committee Chairmen:

General Chairman: John D. Ritchie, Douglas Fir Plywood Association, Tacoma, Wash.

Finance & Treasurer: Robert D. Pauley, Weyerhaeuser Timber Co., Tacoma, Wash.

Program Chairman: Moss B. Christian, Chicago Mill & Lumber Co., Tallulah, La.

Publicity Chairman: Perry Culp, Jr., Cole & Weber, Advertising, Tacoma, Wash.

Arrangements Chairman: Fred R. Armbruster, The Dow Chemical Co., Seattle, Wash.

Registration & Tickets: Harold R. Evans, Plywood Research Foundation, Tacoma, Wash.

Hotel and Housing: Robert Williams, American–Marietta Co., Seattle, Wash.

Group Meals, Banquets, Entertainment: Earl McCarthy and Keith Binder, American–Marietta Co., Seattle, Wash.

Ladies Program: Mrs. Earl McCarthy, Seattle, Wash.

Information & Hospitality: John Hefferline, Laucks Laboratories, Inc., Seattle, Wash.

Paul Bunyan Potlatch and Transportation: William Hempelmann, Monsanto Chemical Co., Seattle, Wash.

Field Trips: Art Walton, Simpson Logging Co., Shelton, Wash., and John S. Abel, Weyerhaeuser Timber Co., Tacoma, Wash.

Meeting Equipment & Supplies: Neal Warne, Seattle, Wash.

Paul Bunyan Potlach Sponsors: O. Harry Schrader, Jr., U. S. Plywood Corp., Seattle, Wash.

NATIONAL MEETING COMMITTEE included, left to right, seated: R. D. Pauley, Fred R. Armbruster, John D. Ritchie, Earl T. McCarthy, Mrs. McCarthy; standing: John Hefferline, Bob Williams, Perry Culp, Jr., Neale Warne, and Bill Hempelmann. Not present for photo were: Dr. O. H. Schrader, Jr., Harold R. Evans, Keith Binder, A. T. Walton, and J. S. Abel.

ONE UNDIVIDED RESPONSIBILITY

TO SOLVE YOUR DUST CONTROL PROBLEMS

Exclusive Kirk & Blum Plenum Main Systems in large North Eastern Toy Manufacturing Plant.

For 48 years, Kirk & Blum has specialized in the DESIGN, FABRICATION and INSTALLATION of efficient, dependable systems for the removal of dust and fumes.

DESIGN: Kirk & Blum engineering specialists survey your plant and then design your system, selecting equipment most suitable for your problem.

CONSTRUCTION: Kirk & Blum fabricates the complete system (equipment excepted), "tailor made" for your installation.

INSTALLATION: The Kirk & Blum contract includes responsibility for the entire system, installed by mechanics with years of specialized experience in the installation of such systems.

● **As a result, you have one undivided responsibility—one *complete contract for an installed system, ready to operate.*** **The Kirk & Blum Mfg. Co., 3231 Forrer St., Cincinnati 9, Ohio**

Dust Collecting Systems at American Mfg. Concern, Falconer, N. Y.

FOR CLEAN AIR . . . THE INVISIBLE TOOL

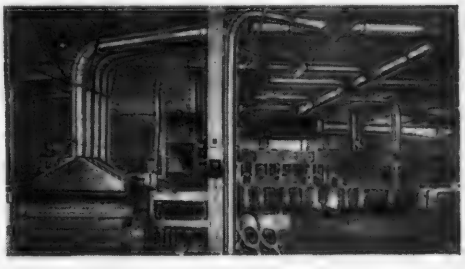
KIRK & BLUM

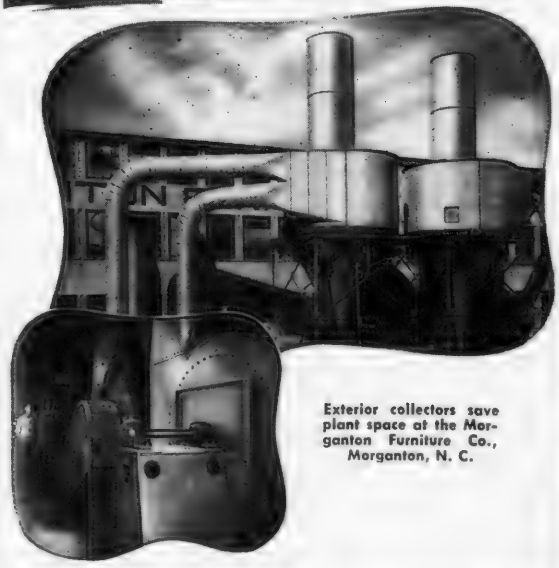
DUST & FUME CONTROL SYSTEMS

WRITE FOR ANY OF THE FOLLOWING BOOKLETS:

"Blower Systems for Woodworking Plants"
"Fan Systems for Various Industries"

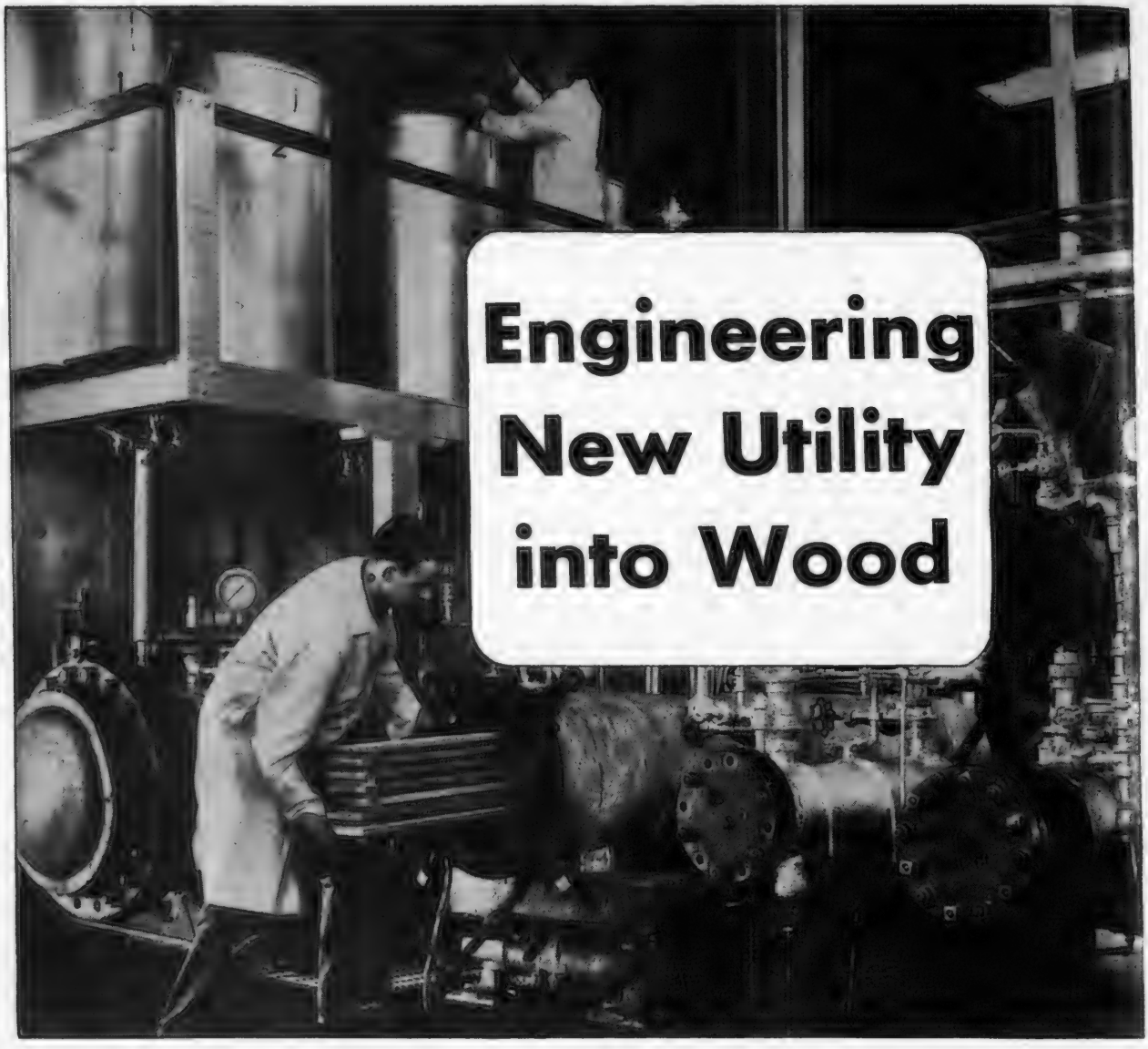
K & B streamlined Tapered Main System for the Sports Products Co., Cincinnati, Ohio.





Exterior collectors save plant space at the Morganton Furniture Co., Morganton, N. C.

This cluster of Cyclones collects sawdust, shavings and chips at the Bernhardt Furniture Co., Lenoir, N. C.



Engineering New Utility into Wood

at the Koppers Technical Laboratory

● Koppers pressure-treated wood products have proved their worth by giving customers long and satisfactory service. But Koppers doesn't rest on its laurels. At its Technical Laboratory in Orrville, Ohio, Koppers works to improve its products so that they will do an even better job.

Here, in one of the most complete and best equipped wood-treating laboratories in the world, Koppers technicians conduct exhaustive tests on the prevention of wood deterioration.

A man-made "tropical jungle" accelerates the rate of decay in wood and thus provides samplings for study. Impact-testing machines determine the loss of strength caused by the various agents that attack wood. There is a battery of pressure cylinders for impregnating wood with various preservatives and for testing all known treating procedures.

This continuing program of research is another way in which Koppers is hard at work to make wood serve industry better and more economically.

KOPPERS COMPANY, INC.

KOPPERS

PRESSURE-TREATED WOOD

Wood Preserving Division, Pittsburgh 19, Pennsylvania

Business Meeting

(Continued from page 31-A)

of the Constitution be changed to read: "The fiscal year shall begin on January 1 and shall terminate on December 31 of the same calendar year." Motion was carried.

E. S. Harrar moved, P. R. Kramer seconded, that Article V, Section 3, of the Constitution be changed to read: "Dues for voting and associate members shall be $15.00 per year, $2.00 of which will be returned to Sections to help defray administrative expenses. Annual dues for the fiscal year will be due and payable on or before *January 1* of each year. Voting, associate, and student members joining up to and including *December 31* shall receive all back publications to which they are entitled for that year." Motion was carried.

Under terms of the Constitution these proposals must be submitted by letter ballot to the voting members at large for ratification.

4. Report of the Audit Committee

The committee consisting of Chairman George W. Johnson, Ralph Simeone, and Herbert O. Fleischer met with accountants Victor Hobert and Dan Richmond, and the Executive Secretary in Madison on June 10. It examined the records and wishes to report that the balance sheet, operating statement, and additional records, as shown separately, reflect a true summary of the financial transactions of the national organization for the year.

The committee commends the Executive Office and accountants for making the financial statement more complete and understandable than in previous years.

5. Report of Publications Committee

During the past year the FOREST PRODUCTS JOURNAL has reached maturity and achieved stature as one of the leading technical journals in the United States. A number of important changes have occurred.

The Annual Review issue has been initiated. The Proceedings issue has been dropped as a result of the change from National Meeting preprints to Abstracts. The major portion of National Meeting papers will be published in the August and October issue of the JOURNAL. The major emphasis in the Annual Review issue is the annual report of each Subject Matter Committee setting forth major developments and status of its field. We desire to express our appreciation to those Subject Matter Committees who did such an excellent job of preparing their first report for publication in the February 1955 issue.

By action of the Executive Board, the title of the JOURNAL has been simplified to FOREST PRODUCTS JOURNAL.

Edward H. Roche has been appointed editor of the JOURNAL. Roche is a journalism graduate of Syracuse University and formerly editor for the State University of New York College of Forestry, Syracuse.

We wish to express appreciation to Howard B. Rosenberry for his excellent work in development of the JOURNAL and to compliment Mr. Roche on his fine work.

In line with the recommendation of the Section officers, the December issue will contain a cross-referenced index by subject and author.

The Executive Office of the Society has conducted a readership investigation. The present balance of papers appears satisfactory to the members. The four most regularly read features were: New Product News, Technical Articles, FPRS News Digest, and New Publications. Contributed research papers have more than doubled during the past year. We would like to emphasize the need to give national distribution to papers presented at Section meetings by their publication in the JOURNAL. Well-prepared and carefully thought-out papers are required.

The FOREST PRODUCTS JOURNAL is published bi-monthly with a circulation of 3,200. From the backlog of papers, both quantity and quality, the JOURNAL now is ready to assume its position as the monthly technical publication for the Forest Products Industry. The Executive Board has approved monthly publication of the JOURNAL, beginning in January 1956.
—E. G. LOCKE, Chairman.

FPRS SECTION MEETINGS, FISCAL YEAR 1955

Date	Section	Place	Subject
Apr. 15, 1954	Ohio Valley	Louisville, Ky.	Kiln drying
Apr. 23, 1954	Northern California	San Francisco	Our responsibilities for wood's future
Apr. 29–30, 1954	Northeast	Williamsport, Pa.	Efficiency in the wood industries
May 17–18, 1954	Pacific Northwest	Aberdeen, Wash.	Hardboard and plywood
June 3–4, 1954	Carolinas–Ches.	Myrtle Beach, S. C.	Chips for pulp operations
June 11, 1954	Carolinas–Ches.	Washington, D. C.	Progress in laminating
June 23, 1954	Pacific Southwest	Los Angeles	Wood waste problems
July 15–16, 1954	Inland Empire	Missoula, Mont.	New sawmill designs, utilization of low-grade species
Sept. 23–24, 1954	Midwest	Madison, Wis.	New modes and materials
Sept. 30, 1954	Northern California	Scotia, Calif.	By-products from redwood utilization
Oct. 11–12, 1954	Carolinas–Ches.	Asheville, N. C.	Furniture production and marketing
Oct. 14–15, 1954	Ohio Valley	Louisville, Ky.	Millwork decay, moisture detection, prefabricated dry kilns, millwork costs, and decorative laminates
Oct. 25–26, 1954	Pacific Northwest	Corvallis, Ore.	
Oct. 28, 1954	Northern California	Chico, Calif.	The pine industry
Oct. 28–29, 1954	Fla.–Ga.–Ala.	Auburn, Ala.	Lumber, plywood, and home construction
Nov. 2–3, 1954	Upper Miss. Valley	St. Paul, Minn.	Minnesota resources, use of small cuttings in wood particle board
Nov. 4–5, 1954	Northeast	New York, N. Y.	What's new in wood
Dec. 1–2, 1954	Great Lakes	Grand Rapids, Mich.	High production methods in the finish mill of a furniture plant
Jan. 7–8, 1955	Mid-South	Crossett, Ark.	Integrated lumber operations
Jan. 20–21, 1955	Inland Empire	Yakima, Wash.	Fiber products, outlook for lumber, and residue utilization
Feb. 28–Mar. 1, 1955	Pacific Northwest	Seattle, Wash.	Forest products in the building industry
Mar. 14–16, 1955	East. Canadian	Ottawa, Ont.	Annual meeting

6. Report of Building Committee

W. J. Eason, Chairman, outlined the progress to-date toward the erection of a National Executive Office building in Madison, Wisconsin. A lot valued at $10,000 with improvements to-date has been purchased and fully paid for, taking up essentially the surplus earnings of the Society. Complete plans for architecture have been approved. The building will be fire-retardant treated frame construction and will be representative of a wide range of forest products materials. Various materials and cash toward the construction and use of the building have been contributed by the following:

Precision Panels Inc.
United States Plywood Corp.
Chester B. Stem, Inc.
Hardwood Corp. of America
Vancouver Plywood Co.
Aberdeen Plywood Corp.
Knight Mfg. & Lumber Co., Ltd.
Arkansas Oak Flooring Co.
Pacific Lumber Co.
Unit Structures
J. J. Fitzpatrick Lumber Co.
Harbor Plywood Corp. of Oregon
Coats, Huddleston & Buck
Elliott Bay Mill Co.
Koppers Co., Inc.
Gamble Brothers
Southern Plywoods, Inc.
Masonite Corp.
The Borden Co.
Paine Lumber Co., Ltd.
The Mengel Co.
Thomason Plywood Corp.
M & M Wood Working Co.
Oval Wood Dish Corp.
Darlington Plywood Co.
Curtis Companies, Inc.
Wells Furniture Mfg. Co.

Jasper Chair Co.
Fiberesin Plastics Co.
E. Gurvitch Lumber Co., Inc.
The Crossett Co.
Soderhamn Machine Manufacturing Co
Midwest Section—FPRS
Harnischfeger Corp.
Edward Hines Lumber Co.

It is estimated that exclusive of donated materials and the lot, the building should be erected at a figure of approximately $30,000. Mr. Eason pointed out that before proceeding further, the Executive Board was considering raising additional funds either by company participation or through cooperation of FPRS Sections desiring to participate in the program. F. H. Kaufert moved, duly seconded, acceptance of the report. Motion carried.

R. E. Shreck noted that Mr. Eason anticipated that the building construction might be underway prior to the time of the next annual meeting to be held in Asheville, N. C. He stated that if it were necessary to finance the building out of future earnings, the membership be given further opportunity to vote on the matter.

7. Report of Membership Committee

President Carr read a wire from F. T. Parrish, National Membership Chairman, stating that because of business reasons he would not be able to be present at this meeting.

It was noted that membership and subscriptions as of June 1 stood at 2,938; and it was confidently expected that the Society would pass the 3,000 goal during the Seattle National Meeting.

Robert N. Smith, FPRS Executive Office, presented membership awards in the form of large felt banners to the following sections:

Inland Empire Section—First Award for greatest percentage membership gain 1954–1955

Northeast Section—Second Award for greatest numerical gain 1954–1955

Northern California Section—Third Award—runner-up 1954–1955

Smith noted that as of the business meeting hour, we had gained 32 new members at Seattle, bringing the total to 2,970. Newell Norton moved, duly seconded, acceptance of the report. Motion carried.

Robert N. Smith reported on a meeting of the Membership Committee and guests held June 21 at Seattle. Attending were: Reavis Sproull, Tony Veazey, William Martin, Wayne Lewis, Roy M. Carter, Harvey H. Smith, John Krier, Herbert McKean, Paul Bois, and Robert N. Smith.

Smith outlined membership activities in the National Office during the past year. He opened the meeting to comments or remarks by committee members present, requesting their suggestions for membership activities on the Section level.

Tony Veazey stated that he attributed his Section's successful membership activities to following the Section Officers' Manual, plus following up the prospects secured at Section meetings immediately after the meetings.

Roy Carter suggested that Hoo-Hoo Clubs may be willing to offer lists of their members as prospects for FPRS.

Wayne Lewis moved and Roy Carter seconded a motion to investigate the possibility of establishing the mechanics and organization of official FPRS student chapters at wood technology and forestry colleges. The purpose would be to stimulate students' interest in forest products utilization by active group participation in FPRS. Roy Carter stated that there already is an unofficial FPRS chapter at N. C. State. Committee members

Complete Service On Wood Preservatives!

TECHNICAL COUNSEL
A full staff of specialists with years of experience and complete laboratory facilities, ready to assist in every way.

ENGINEERING SERVICE
An experienced engineering department to help in planning, designing and installing new pressure-treating plants; modernizing old plants; selecting equipment to meet your specific needs.

WOODTOX Penta Preservative and Water Repellent
A clear, clean, non-staining treatment combining advantages of Penta plus resistance against swelling, warping, shrinking and other moisture damage. Meets NWMA and Western Pine Assoc. preservative standards.

PENTAchlorophenol WOOD PRESERVATIVES
Most satisfactory and permanent of all wood preservatives against decay, fungi, termites and other wood boring insects.

NOXTANE SAP STAIN CONTROL
Most effective, safe and economical treatment made for protection against sap stain fungi. Leaves wood bright and clear. Quick solubility, dustless, non-irritating. Won't damage metal equipment.

EQUIPMENT
Exclusive national sales agents for Efurd Machine & Welding Company, builders of Hurricane Debarkers, Peelers, Framers, Incisors, Trams, etc.

Whatever your problem in the protection and preservation of forest products, this is where you can always get the *right answers quick!* Write or phone.

WOOD TREATING

WOOD TREATING CHEMICALS CO.
5137 Southwest Avenue St. Louis 10, Missouri

LEADERSHIP IN THE PLANER MATCHER FIELD SINCE 1907

This Trade Mark

ON MACHINES IN YOUR PLANT MEANS

HIGHEST PRODUCTION
MAXIMUM QUALITY
LOWEST PRODUCTION COST

THE most profitable planing mills in operation today are those planned for continuous straight-line production and minimum lumber handling. The heart of such a production line is a quick-change, fast feed modern planer and matcher that produces finely machined lumber—and does it a full 8 hours per shift. There is no place in *today's* planing mill for the machine that ties up production a half hour or more each time a pattern is changed.

New machine developments during the last 20 to 25 years have made the equipment of an earlier era obsolete—*obsolete long before it is worn out.*

If you are using ancient machines in your planing mill just because they aren't *worn out* yet, we suggest that you honestly compare the equipment you are now using with the available new equipment on the market. Then, determine how much this obsolescence is actually costing you.

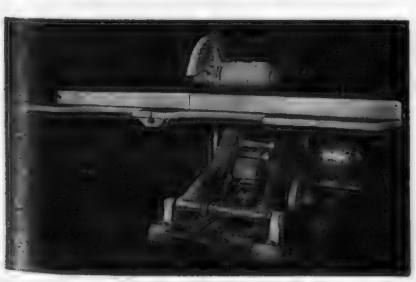
We believe you will be agreeably surprised at the many *years-ahead* features found in Stetson-Ross cost-reducing planing mill machines.

You are invited to submit planing, trimming or handling problems for our recommendations without obligation. FREE ON REQUEST: *Your copy of "A B C's of Planing Mill Layout."*

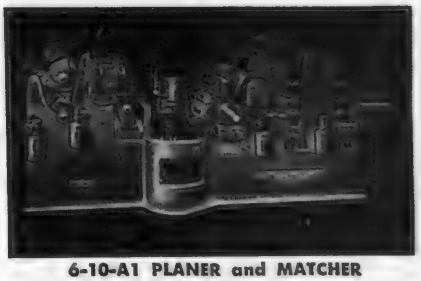
TRAVELING APRON DECK-CONVEYOR
603-E UNLOADER HOIST

T-33 RANDOM LENGTH TRIMMER
with built-in top and bottom dust removal system

WT-65 AUTOMATIC BUNDLE TRIMMER



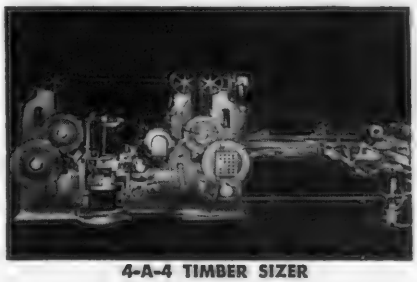
T-18 CUT-OFF SAW



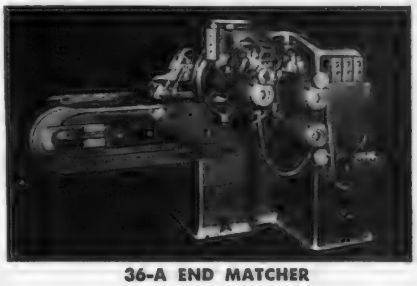
6-10-A1 PLANER and MATCHER
(8 Knife)

202 TWO-WAY THICKNESSING PLANER
and MATCHER
(14 Knife)

6-12-C1 PLANER AND MATCHER
(14 or 16 Knife)



4-A-4 TIMBER SIZER



36-A END MATCHER

STETSON-ROSS
MACHINE COMPANY
SEATTLE 4, WASHINGTON

EXPORT DIVISION: 301 CLAY ST., SAN FRANCISCO 11, CALIFORNIA

suggested that FPRS Sections help by providing speakers at student chapter meetings.

Reavis Sproull suggested that Section Membership Chairmen serve for a three-year term rather than for one year. He felt that more time is needed to provide better continuity of effort.

Smith was asked to forward a copy of the minutes to each Section Membership Chairman. It was suggested that he ask the Chairmen to follow up Section Meeting attendee prospects within 30 days after the meeting.

8. Report of 10th National Meeting Committee

Chairman E. S. Harrar reported on the 1956 National Meeting to be held in Asheville, North Carolina, June 4–7, 1956. He called attention to the special Asheville newspaper issue circulated among the registrants at the Seattle meeting, outlining the points of interest in and around Asheville. He indicated that in addition to the customary technical sessions and committee meetings, the 1956 meeting would also embody educational Table-Top Exhibits of interest to all forest products industries. M. B. Christian moved, duly seconded, the report be accepted. Motion carried.

9. Report of Subject Matter Committees

Co-ordinator R. H. Bescher described the scope of FPRS' 13 standing committees in special fields of the wood-using industries. (See page 69A). He noted that the primary duties of the committees are: a) preparation of National Meeting program; b) development of summary annual report for publication in the FOREST PRODUCTS JOURNAL. Bescher stressed the need for complete balance of membership on each committee so that all interests in any field may be represented. On motion duly made and seconded, the report was accepted.

10. Report of Resolutions Committee

1. The Society records with deep regret the passing during the past year of the following members: Ross Langill, Joseph I. Steel, E. R. Linn, W. W. Varossieau, Ragnar Schlyter, J. L. Bienfait, Emil A. Anderson, Carl Pandel, W. L. Burritt, Harold F. Rubin, Ralph A. Bond, D. C. Daly, Albert B. Maine.

Be it resolved that this expression of sympathy to the families and friends of these men be included in the permanent records of this meeting and of the Society.

2. In appreciation of the meritorious services that have been rendered to the Forest Products Research Society during their term of office,

Be it resolved that the gratitude of the Society be extended to all of our outgoing officers including Executive Officers, Regional Board Members, and Section Officers.

3. Recognizing that the success of this Ninth Annual Meeting of the Forest Products Research Society is in a large measure due to the foresight, planning, and diligence of the Annual Meeting Committees,

Be it resolved that the Society hereby acknowledges its appreciation to the Chairmen and members for their excellent and successful work.

4. In view of the splendid cooperation and services provided by our host hotel, the Olympic, in helping to make this Annual Meeting a success,

Be it resolved that the appreciation of the Society be extended to the management and the staff.

5. Recognizing the contribution that the Paul Bunyan Potlatch Sponsors have made to the social portion of our meeting,

Be it resolved that the Society extends its appreciation to the Sponsoring Companies and Organizations.

Check

GAMBLE BROTHERS

Their fifty years of leadership in wood engineering will help you solve your production and redesign problems . . . without obligation.

They can fill your needs for solid or laminated hardwood parts . . . rough . . . or finished, ready to assemble . . . in Southern and Appalachian hardwoods, walnut and mahogany.

Write today!

Engineered Wood Parts in Southern and Appalachian Hardwoods, Walnut, or Mahogany.

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6. Because of a significant contribution which has been made to the industry by one of our Supporting Members during the past year,

Be it resolved that the Executive Board of the Forest Products Research Society take such action as it deems appropriate to acknowledge this contribution and to properly express the appreciation of the Society to the Weyerhaeuser Timber Co. for making public the now well known "Stanford Report."—K. G. CHESLEY and ROY M. CARTER

11. Report of Tellers Committee

Your Tellers Committee, composed of A. K. Esterer, W. C. Lewis, R. P. Nelson, R. N. Smith, and the Chairman, have counted the ballots and report the following elected: President-Elect, R. H. Bescher; Vice-President, F. H. Kaufert; North Central Region, R. L. Hiller; Southwest Region, R. H. Berry; 1956 National Nominating Committee: J. S. Bethel, J. B. Grantham, J. H. Jenkins, W. L. Lear.

Submitted by George W. Stanley, Jr., Chairman. Upon motion duly made and seconded, the report was accepted.

12. Introduction of New Officers

Retiring President L. J. Carr, after seven continuous years on the Executive Board, acknowledged with gratitude the services as Regional Board Members of R. E. Shreck, Union Lumber Co., San Francisco, Calif., and Dr. J. A. Hall, U. S. Forest Products Laboratory, Madison, Wis., both of whom have served three years on the Executive Board. He then introduced incoming members of the Executive Board: Vice-President Frank H. Kaufert, University of Minesota, St. Paul, Minnesota; North Central Region, R. L. Hiller, American Cyanamid Company, Chicago, Ill.; Southwest Region, R. H. Berry, Scott Lumber Co., Burney, Calif.

Mr. Carr concluded with appreciation to the many officers and committees of FPRS' 13 Sections and to the Executive Office staff; and introduced his successor as President, Moss B. Christian, Chicago Mill & Lumber Co., Tallulah, La. President Christian acknowledged his introduction by expressing esteem for the work of his predecessors and expressed the hope that together all of us in FPRS will continue to move forward under his year of presidency.

13. New Business—Executive Office Building Program

R. E. Shreck, feeling that the Society is not in a position at this time to proceed with a building program, moved, duly seconded, that a ballot vote of the membership be taken before any financial commitment on the part of the Society, to get members' approval or disapproval of the intended program. Homer Stephenson moved, Edward G. Locke seconded, that the motion be tabled on the basis that the matter of a poll on matters within the province of the Executive Board is one of Executive Board authority and discretion. The vote was 31 to table; 30 opposed. On recount the vote was 33 to table, 31 opposed, 7 not voting. R. H. Bescher, Chairman of the Executive Office Building Funding Committee, stated that the Executive Board will be guided by sound financial practices in any venture which it undertakes for the benefit of the members.

14. Adjournment

President M. B. Christian declared the meeting adjourned at 12:15 P.M.

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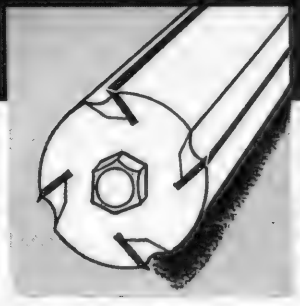

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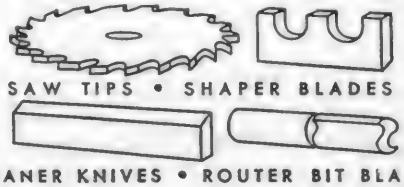

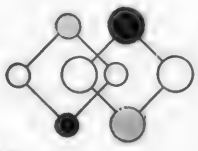

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Section Officers Propose Eight-Point Program for 1956

The traditional luncheon meeting of members of the National Executive Board and Section Officers and their delegates was held at the Olympic Hotel, Seattle, at 12:30 P.M. June 23, 1955. The following persons attended: Moss B. Christian, Tallulah, La.; L. J. Carr, Sacramento, Calif.; Ralph H. Bescher, Pittsburgh, Pa.; Frank H. Kaufert, St. Paul, Minn.; R. D. Pauley, Tacoma, Wash.; E. S. Harrar, Durham, N. C.; W. Jeter Eason, Memphis, Tenn.; Ray Shreck, San Francisco, Calif.; R. H. Berry, Burney, Calif.; R. L. Hiller, Hartland, Wis.; D. K. Saunders, Westbrook, Maine; Newell A. Norton, State College, Pa.; Eric A. Anderson, Syracuse, N. Y.; James S. Bethel, Raleigh, N. C.; Reavis C. Sproull, Savannah, Ga.; Paul R. Kramer, Lufkin, Texas; W. J. Tomford, Memphis, Tenn.; Charles Schenker, Cincinnati, Ohio; G. G. Garlick, Kalamazoo, Mich.; S. B. Preston, Ann Arbor, Mich.; L. A. Patronsky, Minneapolis, Minn.; Wayne Lewis, Madison, Wis.; Dwight W. Bensend, Ames, Iowa; Tony Veazey, Butte, Mont.; R. W. Wellwood, Vancouver, B.C.; H. R. Evans, Tacoma, Wash.; A. R. Colman, Montreal, Que.; H. N. Stephenson, Sacramento, Calif.; J. Rowney, Oakland, Calif.; F. J. Rovsek, E. H. Roche, and R. N. Smith, Madison, Wis. Not present were: F. T. Parrish, Gardner, Mass.; J. A. Hall, Madison, Wis.; J. D. Ritchie, Tacoma, Wash.; and a delegate from the Pacific Southwest Section.

EXECUTIVE BOARD—SECTION OFFICERS ADVISORY COMMITTEE

1. The Minutes of the May 6, 1954, combined Executive Board-Section Officers Advisory Committee meeting were reviewed. It was noted that the Executive Board and the Executive Office had given attention to every recommendation in those Minutes.

2. Proposed Executive Office Building. It was reported that the Executive Board would name a new Funding Committee for purposes of obtaining additional finances toward the erection of this building. At the present time the Society is in need of a considerable additional sum of money before it can proceed further.

3. It was announced that on the recommendation of the Executive Office and Publications Committee, the FOREST PRODUCTS JOURNAL would be published monthly beginning in 1956.

4. Robert N. Smith of the Executive Office announced that this Ninth National Meeting had been productive of some 30 new memberships. He emphasized the need for greater membership activity in the Sections throughout the year.

5. Newell A. Norton described the growing FPRS National Employment Service, which now covers: job openings, experienced applicants, relatively inexperienced applicants (recent college graduates), and students seeking summer employment. Mr. Norton indicated that at Seattle we had handled some 20 contacts for employment, not including interviews we arranged. Since the Grand Rapids Meeting, we have had 81 applications for employment. Mr. Norton emphasized the need to publicize the information that FPRS is in the employment field. He also indicated that the National Em-

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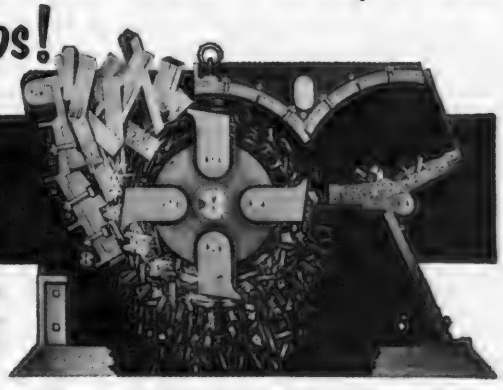

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ployment Committee would shortly be active at the Section level, and that each Section should begin to give some thought to employment activity and coordination with the National Committee. Mr. Norton will be in contact with the Sections regarding proposals in this direction.

6. Instructions for guidance of sections regarding their legal prerogatives and obligations were read in detail. These were prepared by Robert C. Voss, Madison, Wis., attorney, at the request of the Executive Board. Wayne Lewis, Chairman of Midwest Section, moved, duly seconded, that a commendation be made to the Executive Board for this action. The motion was carried. The Executive Secretary was instructed to send a copy of this legal guide to all Section officers.

7. The Section Officers Advisory Committee submitted a list of eight subjects on which they would like to see solutions or progress in the coming year. Proposed were: a. Suggested bookkeeping system for Sections, including instructions and forms; b. Model Section By-Laws; c. Revised membership application blank providing for faster notification of new members to Section Secretaries; d. Continued diligence in present monthly membership change lists; e. Added emphasis on "memberslips"; f. Growth of Employment Committee; g. Schedule morning or afternoon Section Officers Advisory Committee Meeting during next National Meeting; h. Long range proposal to consider establishment of a corollary FPRS Institute of Research.

Each point of the recommendations was read and discussed, with the following commitments by the Executive Board:

a. Uniform Section Bookkeeping Systems. It was pointed out that we have just reached the point where we are now getting regular accurate reports of Section finances, and the Executive Office feels it is now in a position to do further work along the lines of setting up a bookkeeping system guide for Sections. The Executive Secretary will report to the Section officers on this project this year.

b. Model Section By-Laws. E. S. Harrar, National Chairman, Constitution and By-Laws Committee, has been working on this project continuously for the past year. He has received copies of most Section By-Laws and has made a comprehensive study of them. As soon as membership is polled and results known regarding change in fiscal year, Mr. Harrar will send each Section Secretary suggested changes.

c. Revised Membership Application Blank. The present supply of application blanks on hand in the Executive Office numbers some 5,000. In addition, we have an equal number or more of membership brochures which contain an application blank. Until most of this material is used up, it will not be feasible to add a new section to the application blank for purposes of early notification to Sections of new members. However, this suggestion will be taken under advisement and will be reviewed at such time as we are ordering new supplies.

d. Changes in Membership. The Executive Office appreciates the recognition of the Sections that they are receiving a duplicated list of membership changes monthly; and will try to be increasingly diligent in the classification of various changes.

e. "Memberslips". The Executive Office now follows this procedure: First invoice — February; second invoice—June, with copies to each Section Secretary so that he may further follow up all delinquent dues; third and final invoice—September, with duplicate copies to Section Secretaries; fourth unofficial, "last effort" invoice —October. The important point here is that the Sections should assist the Executive Office on follow-up on delinquent dues. By this procedure we have materially increased our effectiveness in holding members.

f. Employment Committee. (See earlier report, Item 5)

g. Annual Section Officers' Meeting. The Executive Board approved a suggestion that a full morning or afternoon period be devoted and scheduled in the official program for the meeting of Section Officers' Advisory Committee. This is the meeting wherein the Sections discuss among themselves their needs, etc., before meeting jointly with the Executive Board at the annual luncheon meeting.

h. Institute of Research. The Executive Board regards this as a very long-range project and defers any action to future Executive Boards. It feels that at the present time there are sufficient wood research laboratories available for industry requirements and that the big problems are:

1. Coordination of these facilities so that industry knows where to take its research problems.

2. The greater dissemination of information emanating from these laboratories.

8. The meeting was officially adjourned at 1:30 P.M.

1955 FPRS Subject Matter Committee Reports

EDUCATION COMMITTEE

EDUCATION COMMITTEE

Education Committee Urges Industry Support

EDUCATION — June 21 — Chairman, A. J. Panshin, Michigan State University, East Lansing, Mich.

The meeting was called to order by Chairman A. J. Panshin. The Chairman reviewed the results of the Industry-Education Meeting held in Madison, Wisconsin in October, 1954, under the sponsorship of the Education Committee. He indicated that the conference was successful except for the fact that very few industry representatives were in attendance. As a result of this conference, three continuing Task Forces were appointed as follows:

(1) A task force to consider the type of training necessary for a professional career in the forest products industries.

(2) A task force to explore ways and means of increasing industry participation in the work of the Education Committee (how to sell industry on the need for technically trained personnel).

(3) A task force to study the problem of attracting high quality high school students into forest products curricula.

The Chairman called on C. F. Van Epps to report on the activities of Task Force No. 1. Mr. Van Epps presented the report of this committee and indicated the areas of agreement. The Chairman asked for comment on this report. D. W. Bensend raised the question of accrediting forest products curricula and pointed out that the Society of American Foresters accredits forest management curricula. He asked whether the SAF should be requested to review forest products curricula or whether some other agency, perhaps the FPRS, was to accredit curricula in this area. Mr. Van Epps stated that if accrediting was to be considered for forest products curricula, the accrediting group must have professional status. He further commented that there was a possibility of establishing a group within the Forest Products Research Society and suggested that if this could be established, perhaps accrediting could be accomplished by the FPRS at some future time. Dr. George A. Garratt suggested that vocational courses might have to be removed from forest products curricula if these curricula were to have professional status. Mr. Van Epps commented that this must be approached gradually since it appeared at the present time that some vocational subjects were necessary. Mr. Van Epps further stated that, in his opinion, it was necessary to get more aid from industry in determining the nature of forest products curricula in the universities.

D. G. Lubeck commented that the committee should contact working wood technologists who are graduates of forest products curricula to find out what their reactions are to the curricula under which they prepared, to changes which have been made in forest products curricula recently, and to changes which are proposed to be made in forest products curricula.

Dr. F. F. Wangaard said that he agreed that a man who has gone through the education mill should be one of the best sources of criticism, both constructive and destructive, of forest products curricula.

The report of Task Force No. 2 was presented by H. O. Fleischer and Chairman Panshin called for comments on this report. Dr. Fleischer commented that apparently FPRS and the universities would not get anywhere selling industry wood technologists, that they must first sell industry on wood technology itself. He felt that this was a job for the Society and for the universities and could not be passed off to outsiders. Fred Gottschalk made the comment that the universities providing forest products technology training had competition in their attempts to place the graduates with industry. He noted that industry hires engineers and foresters and other technically trained personnel. He suggested that one of the problems in getting forest products technologists into the wood industries was that of terminology, that the wood industries do not know what a wood technologist is. They are confused sometimes because these men come from schools of forestry and those in the manufacturing phase of the wood products industries are not interested in forest managers.

Dr. Garratt suggested that patience was required. He pointed out that much progress had been made in the past ten years—that wood technologists who have left universities and gone into industry and have been successful are the best salesmen that the wood technology curricula have. He noted that many companies do recognize the need for wood technologists and employ them readily. He also pointed out that another small group of people in industry who can be helpful in calling industry's attention to the potentialities in employment of wood technologists are those people who have been teachers in the forest products curricula and who are now employed in the wood industries.

Dr. H. B. McKean said that the Education Committee should have two basic objectives. One was to get the best possible forest products curricula and to attract the best students into the curricula. He believes that curricula problems can be worked out. He felt, however, that the problems of getting good students into the curricula were much greater.

L. A. Patronsky noted that it was unfortunate that the wood industry was made up of small units. He pointed out that a wood technologist being employed by a small manufacturing organization was likely to become an office boy, accountant, and a good many other things in addition to being an engineer or a technologist. He is likely to find himself required to do many jobs other than the one he was hired to do. In the large manufacturing organizations, such as General Electric and Westinghouse, definite on-the-job training programs are established. In the smaller wood industries, however, this has not been done and may, in fact, not be practical. In many small wood industries, the requirements for technical people are small and the wood technologist who does get in a small plant may find himself alone.

Dr. Panshin pointed out that the discussion was getting into the area of the third task force and suggested that it would be appropriate to hear the report of Task Force No. 3. This report was given and the Chairman asked for comments on it.

Mr. Patronsky stated that industry would welcome opportunities of passing on information to high school students about the forest products curricula that are available. He suggested that some form of publication or handout be made available to industry to pass on to students.

Dr. McKean said that he agreed with Mr. Patronsky on the need for brochures. He felt that these would not only be useful in calling the attention of high school students to careers in the forest products industries, but they would also help in educating managers of forest products manufacturing facilities in the need for wood technologists and the contributions that wood technologists could make to their manufacturing operations. He also pointed out that this might be a means of getting new FPRS members among management personnel. Dr. McKean suggested that the idea of preparing a brochure be again submitted to the Executive Board and he indicated that as a bare minimum in this presentation, an outline of the proposed brochure should be submitted, and as a maximum, a draft of a completed brochure should be submitted.

Manpower Requirements

Dr. Panshin called attention to the recommendation in the report of Task Force No. 3 regarding the possibility of getting the American Forest Products Industries, Inc., to help on the preparation and publication of a brochure on a career in forest products. Dr. Fleischer raised the question of the source of information upon which to base a brochure. He indicated that data were not available on the technical manpower requirements of the forest products industry now and in the future. He pointed out that the Stanford report, while it examined markets and raw material resources, included no study of manpower requirements. S. B. Preston suggested that while the idea of a brochure was a good one, it did not provide the entire answer to the questions that had been raised. He pointed out that high school counselors were flooded with brochures and that there was a need for personal contacts between FPRS personnel and high school teachers and students. He indicated that the National Association of Furniture Manufacturers was doing this and suggested that other wood industry trade associations might adopt the same program.

Dr. Garratt suggested that one platform on which we can make our pitch was the High School Career Day. He felt that it was necessary to have a brochure that could be left with the high school students after a Career Day presentation. He pointed out that we should begin on a small scale and build up to something more elaborate as we get the program underway.

Dr. George Marra suggested that we should attempt to get information on forest products curricula into the hands of men working in woodworking plants with the view of getting their sons to enter into this type of training. Dr. Panshin pointed out that the high school student needs to know what the potentialities are in a career with the forest products industry. He noted that the high school student wants to know what sort of salary he can demand. In this respect, he is comparing the opportunities in the forest products field with the opportunities available in other technical fields. Dr. Panshin also pointed out that many people, including many high school students, do not understand that schools of forestry are related to training in wood utilization. He felt that forestry schools might perhaps broaden their names to reflect a wider base.

Dr. Ben S. Bryant noted that the University of Washington has had a great deal of opportunity for contacting high school students. He said that the University of Washington develops interest in the forest products field among students who are interested in the general field of forestry. He pointed out that it was worthwhile to leave literature after you have made your personal contact. In the West, Dr. Bryant noted, it is possible to get information from the West Coast Lumbermen's Association and other wood products trade associations to use in student recruitment. He stated that the University of Washington was planning to make up a packet of leaflets and other printed material to go to all high schools in the state.

Dr. Garratt called attention to the bulletin "Your Career in Pulp and Paper", which was put out in Maine in support of the University of Maine's pulp and paper program. He commented that this was a very effective bulletin and might serve as a pattern for the kind of thing that FPRS should undertake.

Mr. Lubeck pointed out that one of the handicaps that the recruiter for a forest products curriculum faces is that the wood products industries too generally have too little to offer in the way of incentives. He noted that salaries offered to college graduates in the wood products field were generally far too low in comparison with those offered to college graduates entering other technical fields.

Dr. Fleischer said that there was much evidence to indicate that industry knows that it has many very real problems. He raised the question as to whether the FPRS Education Committee could sell industry on the fact that technical personnel is perhaps its biggest problem and to get it to invest possibly as much as $100,000 in selling high school students on entering into forest products technical training.

Too Specialized

Robert Scott said that he would like to express the point of view of the man who is responsible for staffing an organization. He noted that many technically trained men coming from universities are too specialized, that they may be qualified to handle the opening which is immediately available, but that they are not qualified to advance to future jobs farther up the line. He noted that some of the questions that he asked himself upon interviewing a technical man were: "Is the man prepared to ascend the ladder, or is he likely to stay at the bottom? Where will the man be 10 to 15 years from now?" He felt that forest products curricula and training programs should recognize the need to prepare a man not only for his first job, but also for his movement up the ladder in a successful career.

Dr. Panshin noted Mr. Scott's comments with interest and said that the schools need definite suggestions on how to do this job. Mr. Scott suggested that one way of recruiting high school students was for the FPRS to prepare basic information and make it available to the larger industries. He felt that these industries might pick it up and publish it. He noted that the chemical industry had done this successfully.

Dr. Newell A. Norton said that the Northeast Section has had an opportunity to get a brochure printed at a very low cost and that they were preparing one with the anticipation of printing 20,000 copies.

W. F. McCulloch raised another problem. He pointed out that a brochure which was prepared for national use might not fit every region. Dr. Panshin said that he felt that a brochure for national use could be general enough to fit all areas. Dr. Wangaard added to this the comment that the national brochure would not supersede local brochures but that it might form a basis for the preparation of local brochures which could be used with it.

A motion was made to convert the Education Committee to an Industry Education Council. The objective of

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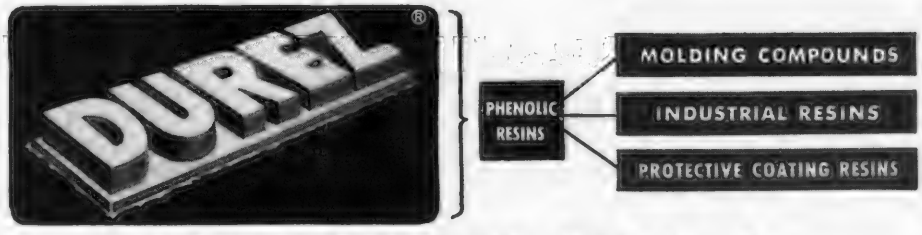

PHENOLIC RESINS THAT FIT THE JOB

this motion was to broaden the base of the committee to provide for more industry participation and to reflect the broad objectives which had been set up for the committee. The motion was seconded. R. W. Wellwood commented that the original terms of the committee did not imply that it should be made up solely of educators and he felt that it was not necessary to make the change proposed. The question was called and the motion was passed.

The motion to adjourn was carried.

GLUES AND GLUING—June 21—Chairman, Alan A. Marra, University of Michigan, Ann Arbor, Mich; Acting Chairman, Ben S. Bryant, University of Washington, Seattle, Wash.

Ben S. Bryant, acting for Chairman Alan Marra, reviewed the appointments of section chairmen to cover the field of glues and gluing. These chairmen are to serve as collectors of information in their assigned areas, and are to transmit reports to the Society membership through the Annual Review. The Annual Review thus becomes a means by which F.P.R.S. members can be kept abreast of developments in this field. Normally these reports would be presented at the annual meeting of the committee and published in a subsequent Journal.

The problem of membership and attendance at subject matter committee meetings was discussed. Membership and attendance is open to all. A standing committee is appointed each year to carry on those activities which require continuity of effort. The thought was again expressed that the latter might be designated by the sections in order to insure regional representation.

A technical session for the 1956 annual meeting was confirmed since gluing is an important part of woodworking in the Southeast. Several topics were suggested, including: gluing of hardwoods, both domestic and foreign; new glues such as contact glues, tape glues, foamed ureas, and epoxy; marine gluing; scarf gluing; end-grain gluing; gluing of dissimilar materials; comparison of high frequency with kiln curing of laminated beams; correlation of accelerated tests with long term service performance; and development of new evaluation methods for glues.

LOGGING AND MILLING—June 21—Chairman, Fred C. Simmons, Northeast Forest Experiment Station

The meeting was called to order by Chairman Fred C. Simmons at 9:30 a.m. George J. Carr was named acting secretary. Mr. Simmons pointed out that this was an open meeting, comments from the floor being solicited.

Report of Committee Activities 1954–1955 period as submitted by K. C. Compton, Secretary, were read by George Carr. Following is context of this report, approved as read:

Report of Activities, 1954–55 FPRS Logging and Milling Committee

The major part of the activities of the Logging and Milling Committee is carried out by the individual members operating in their own territories. So far as possible the membership of the two subcommittees—Logging and Milling—is made up of representatives of each of the important timber producing regions throughout the country. The individual members represent the Committee in their own areas, participating in the programs of their own FPRS Sections, cooperating with other organizations interested in the field in their localities (such as the various regional lumber trade associations, logging congresses, and forestry groups), and acting as outposts of the National Committee to keep it informed on developments in the subject matter field in their area. This type of organization is considered necessary because logging and milling are still strongly regionalized, and most regions have peculiar problems of their own.

National Activities: One result of this type of organization is the report on developments in the two subcommittee subject matter fields, prepared by the subcommittee chairmen, for each of the past two years, and published in the FOREST PRODUCTS JOURNAL. Contributions have been solicited from all of the committee members for both of these reports, resulting in reasonably good coverage of significant developments throughout the United States and Canada. Committee members Matson, Mety, Bell, Thomas, and Hooker have prepared papers for the 1955 National Meeting.

Section Activities: Committee members have played an important part in instigating and participating in meetings of their local FPRS Sections in the subject matter field. Examples are the Carolinas–Chesapeake meeting on use of sawmill residues for pulp chips last summer in which Committee Member Russ Gustafson was an important participant, and the Northeast Section meeting on primary processing this spring, at which Ken Compton presented a paper on sawmill operation.

Cooperative Work: Examples of cooperation with other organizations are the sawmill clinics organized and put on by Subcommittee Chairman Milton Mater at the Redwood and Willamette Valley Logging Congresses last summer, and the first Northeastern Logging Congress, organized by Committee Chairman Fred Simmons. Committee Members R. D. Carpenter, Ken Compton, J. A. Doyle, and Lee Hooker were participants in this latter affair.

The major example of cooperation with other groups was the American Standards Association project on performance standards for small sawmills. The ASME, FPRS, and about 50 other organizations participated in this project. Committee Members Fred Simmons, Ken Compton, and Ernest Clevenger have represented FPRS at the various meetings and many other committee members have supplied advice and help through correspondence. The Logging and Milling Committee was delegated the job of preparing a handbook for small sawmill operators to implement the proposed standard. This handbook, which is now in its second review edition, is now being circulated throughout the country for criticism and comment by interested persons and agencies. Various sections were prepared by committee members Simmons, Compton, Bell, Mater, Clevenger, Thomas, O'Neil, Carpenter and Sims. This handbook may be published serially in the FOREST PRODUCTS JOURNAL, and then, if enough orders are received to justify it, published separately in a pocket edition.

Day-to-Day Jobs: Committee members are working to carry out the objectives of the committee in their day-to-day jobs. Committee member Elmer Matson was primarily responsible for the introduction of the Wyssen Cableway in the Northwest. Committee members Bell and Doyle are conducting basic research in the mechanics and economics of the subject matter field in Canada. Committee member Sims is in the forefront of the trend toward barking of sawlogs and chipping the slabs, edgings, and trim in the South. He has contributed importantly toward the application of metal detectors to wastewood conveyors. Milton Mater is one of the foremost exponents and practitioners of the mechanization of the small sawmill. Committee member O'Neil is very active in the Central States Region. Other examples could be cited, but they would be too numerous to mention.

Respectfully submitted,
K. C. COMPTON, *Secretary*

In response to a question from the floor Mr. Simmons reviewed in further detail the cooperative project to set performance standards for small saw mills, with the American Standard Association, tracing the history of the project starting thru the Munitions

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Board, U. S. Defense Department; the liaison with the American Standards Association, FPRS and ASME; and finally with the American Lumber Standards Committee and National Hardwood Association. The FPRS Executive Board has endorsed the handbook as an educational project. Mr. Simmons pointed out that FPRS is not in the standards business. It can supply information basic to the formulation and carrying out of such standards by organizations such as the National Hardwood Association and the various lumber inspection bureaus.

Mr. Herrick asked whether the complete findings of the ASME committee study on the accuracy currently being attained by small sawmills throughout the country would be published. Mr. Simmons advised that the data collected are now being analyzed at the N. C. Wood Products Laboratory, under the direction of Dr. J. S. Bethel, and that publication of the results separately is contemplated.

Mr. Mater asked whether there was anything further that could be done to encourage more accurate cutting. Mr. Simmons replied that when the basic data is published, it will be available to purchasers of lumber from small mills, and to the various lumber inspection bureaus, for such tests of its applicability, and actual applications, as they wish to make of it. Some encouragement of such tests and applications can properly be given by committee members.

Under the heading of General Committee Business, the functions and organization of the joint committee on logging and milling were discussed. Specifically it was asked whether the separation of these two subject matter groups, now organized into subcommittees, should be recommended to the FPRS Executive Board. It was pointed out that generally a FPRS member is interested and qualified in one field or the other, rarely in both. On the other hand logging and milling are closely allied and interdependent, and many activities such as debarking and log making can be carried out either in the woods or at the mill. A final resolution was developed recommending continuation of the joint committee at least for another year, but more active independent effort to be undertaken during the year by the respective subcommittees, under the general direction of the Committee Chairman.

Projects to be undertaken for the coming year were suggested by those in attendance as follows:

1. Compilation of glossaries of terms.
2. Standardization of conversion units for forest products.
3. Examination and reconciliation of log scales and lumber recovery.
4. Investigation and report of legislative action affecting logging and sawmilling.
5. Encouragement of rather detailed logging studies, and statistical analysis in the various regions.

This list was referred to the subcommittee chairmen for consideration and appropriate action.

A paper was presented by Walter H. Koepp, Forest Products Research Division, Michigan College of Mining and Technology, Houghton, Mich., entitled, "Pulp Chips and Tanbark from Hemlock Slabs by Air-Flotation."

Dr. Hubert Hilf, Professor from the Institute of Forest Work, Hamburg, Germany presented an illustrated report covering studies in human engineering. He pointed up basic differences between woods and lumbering conditions in the U.S.A. vs. Germany (i.e., In Germany they have high-priced wood and low-priced labor, whereas in America we have low-priced wood and high-priced labor).

Dr. Hilf's slides gave suggestions for work signs, safety, and illustrated some of the studies they have made on the human effort required for various jobs.

Mr. Willard Pratt briefly summarized the paper prepared by W. H. Parks on the subject, "Economics of Debarking Redwood Logs".

Following the meeting, Mr. Simmons and Mr. Mater met to consider the future program and membership of the Sawmilling Division of the Committee. The United States and Canada were divided into 23 separate lumber producing regions such as Northeastern Hardwoods, Northeastern Softwoods, Appalachian Hardwoods, Southern Pine, Southern Hardwoods, and Southern Cypress. Candidates for membership in the Sawmilling Division were suggested for each of these regions. The candidates are currently being solicited as to their interest in becoming members before their nominations are submitted to the FPRS Executive Board. (See complete report of proposed program, which follows this report.)

The resignation of L. W. Hooker of the Michigan College of Mining and Technology as Chairman of the Logging Division of the Committee was also received following the meeting. George J. Carr, Pacific Car and Foundry Co., has accepted nomination as Chairman of this Division and is now working on membership and program plans for the current year.

Attending the meeting were: Hubert Hilf, Hamburg, Germany; James R. Wells, Seattle, Wash.; H. S. Manning, Seattle, Wash.; N. C. Bye, Philadelphia, Pa.; Al McCorkey, Seattle, Wash.; Willard E. Pratt, San Francisco, Calif.; Neale Warne, Seattle, Wash.; E. E. Matson, Portland, Ore.; R. D. Lane, Carbondale, Ill.; Walter H. Koepp, Houghton, Mich.; Lionel Pease, Seattle, Wash.; David P. Thomas, Seattle, Wash.; James L. Overholser, Corvallis, Ore.; Paul Heller, New Westminster, B. C.; Dean C. Brice, Portland, Ore.; L. R. Pugh, St. Maries, Idaho; Milton H. Mater, Corvallis, Ore.; David E. Herrick, Carbondale, Ill.; Kenneth W. Duff, Seattle, Wash.; George J. Carr, Renton, Wash.; and Fred C. Simmons, Upper Darby, Pa.

Guests of honor were: Counsel of the German Republic (West Germany) and the Commercial Attache, German Consulate, Seattle, Wash.

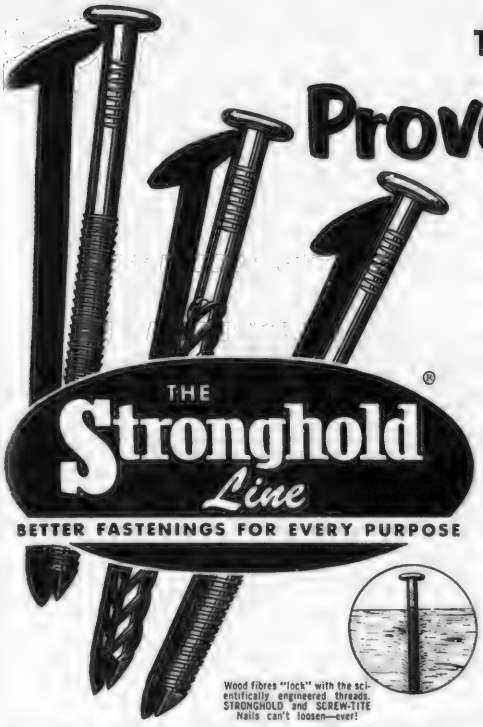
The meeting adjourned at 11:35 a.m.

Sawmilling Subcommittee — Chairman, Milton H. Mater, Mater Engineering

Following the Logging and Milling Subject Matter Committee meeting, it was decided to enlarge the Milling Division, which has to do primarily with sawmilling. It was felt that the great interest in the mechanization of sawmills and in more scientific control of the efficiency and quality of lumber products warranted an increase of the committee membership to better represent the various regions in this country, Canada, and Mexico.

Briefly the regions have been divided as follows: Region 1a: Northeastern U. S., Softwood; Region 1b: Northeastern U. S., Hardwood; Region 2: Appalachian Region; Region 3a: Southeastern U. S., Softwood; Region 3b: Southeastern U. S., Hardwoods; Region 3c: Southeastern U. S., Cypress; Region 4: Central Region; Region 5: Lake States; Region 6: Northwest Pine Region; Region 7: Southwest Pine Region; Region 8: California Pine Region; Region 9: Redwood Region; Region 10a: Douglas Fir Region; Region 10b: Northwest Hardwood Region; Region 11: Canadian Douglas Fir Region; Region 12: Canadian Western Pine Region; Region 13a: Eastern Canadian Softwood Region; Region 13b: Eastern Canadian Hardwood Region; and Region 14: Mexico.

These divisions were made arbitrarily and are subject to modification in the future. The sole criterion was: Is this region set off from other regions by the existence of a type of sawmilling practice peculiar to the region? The reason for using this criterion was the desire to further one of the aims of the FPRS: To make possible an exchange of information on dif-



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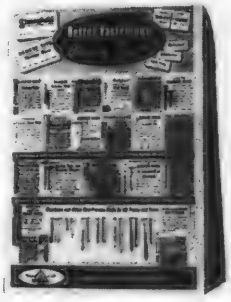

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ferent forest products practice, with a view to increasing efficiency. By crossing regional and species lines, we will keep each other and the forest products industry in general informed as to developments in the various parts of the U. S. and neighboring countries.

As a corollary to the enlargement of the committee, it has been decided to recommend the appointment of Area Chairmen in the broad general areas involved to decentralize the control of the various functions. Four general areas have been designated: Area I. Northeastern U. S. and Eastern Canada; Area II. Southeastern U. S.; Area III. Western U. S.; Area IV. Northwestern U. S. and Western Canada.

The duties of the Area Chairman are:

1. Coordinate the activities of the Regional Committee Members in their areas.

2. Recommend Committee Members to the Chairman of the Milling Division.

3. Supervise the carrying out of Committee projects by the members in their areas and correlate reports for their area.

4. Coordinate the initiation of project suggestions by the Committee members in their area.

Duties of Committee Members are:

1. Carry out and report on Committee projects to the Area Chairman.

2. Initiate suggestions for Committee projects.

3. Keep abreast of developments in the member's Region and prepare Annual Report for publication.

4. Advise local sectional officers on developments in the sawmilling field, and help arrange local FPRS programs in the subject matter field.

5. Cooperate with other local organizations as representative of FPRS and the Sawmilling Division.

WOOD FINISHING—June 21—Chairman, E. Sigurd Johnson, N. C. State College; Acting Chairman, Roy M. Carter, N. C. State College

Roy Carter was designated by Chairman E. Sigurd Johnson to conduct the meeting. The Finishing Committee report for 1955 was read to those attending as prepared by the Committee and submitted to F.P.R.S. Executive Secretary Frank Rovsek by Committee Chairman Johnson.

Discussion of Finishing Problems:

(1) The problem of preventing bleed-through of pitch from softwood knots has not been solved. In natural finish millwork and paneling during manufacture and distribution, pitch continues to exude from knots causing a discoloration of other pieces in panel and lumber stacks. The discoloration is very objectionable and occurs even though the wood is prefinished before stacking or bundling for shipment. Mr. Hooper was aware of this and Mr. Sarvis of Western Pine Association and Mr. Johnson of the Oregon Forest Products Laboratory reported that they were planning more thorough investigations of the cause and possible solution.

(2) Natural exterior finishes need further improvement. One reason for lack of improvements in natural finishes indicated was the failure of finishing material manufacturers to recognize the actual and potential market for clear exterior finish. A survey was suggested to determine the real significance of natural exterior finish to the wood products industry and the ultimate consumer.

(3) More research on the fundamentals of breakdown of clear exterior finishes and wood surfaces was recommended.

(4) Pretreatment of wood to be coated with a clear exterior finish, involving the use of water repellent preservatives in the manufacturing plant, involves production problems. This treatment is designed to prevent stain and discoloration under the clear exterior finish after periods of service. Problems of ventilation, vaporization of carriers, and adhesion of the finish need to be investigated separately and collectively for exterior use.

(5) It was suggested to refer all of the questions on exterior finishes to a subcommittee that would confer with the California Redwood Association and the Golden Gate Paint and Varnish Production Club. The latter club is studying clear exterior finishes for pines and other woods.

(6) Recommended test specifications should be developed for exterior finish, clear and pigmented. Someone commented that the National Lumber Manufacturers Association and the National Paint, Varnish and Lacquer Manufacturers Association were working on material standards and specifications.

(7) Problems in furniture finishing involved discoloration of the finish from various causes, including rubber and exposure and discoloration of the wood under the finish. D. G. Lubeck of Hammond Organ Company, Chicago, Illinois, has prepared a paper on "A Method of Evaluating the Discoloration of Finished Furniture". He has also been working on methods of evaluating scratch resistance, finish adhesion, and filling as applied to furniture finishing. This group recommended the appointment of a subcommittee on furniture and interior woodwork finishing. One of their immediate jobs could be assembling the information from various finishing material manufacturers and suppliers on "discoloration and its reduction in furniture and paneling".

Technical Session Discussion:

This group recommends a technical session on Wood Finishing at the next annual meeting in Asheville, N. C. Topics and possible contributors suggested were:

1. Determining scratch resistance, adhesion, filling, and discoloration of furniture finishes, by D. G. Lubeck, Hammond Organ Co.

2. Evaluating cold check resistance of furniture finishes, by Roy M. Carter and W. J. Schrumpf, N. C. State College.

3. Panel discussion of factors involved in deciding the type of top coat material to use in finishing furniture.

a. Synthetic coatings.
b. Hot lacquer.
c. Cold lacquer.
d. Varnish.

Economic factors, R. Dolman Bibby, The Lane Co.

Finishing qualities and durability, R. I. Quigley, The Lilly Co.

Plant application and production procedures and requirements, M. Carey, Drexel Furn. Co.

From the standpoint of greater interest and activity the following subcommittees were suggested:

A. Furniture and Interior Woodwork Subcommittee: D. G. Lubeck, Hammond Organ Co.; Roy M. Carter, N. C. State College; R. I. Quigley, The Lilly Co.; P. F. De Saix, Carborundum Co.; F. H. Thomas, Sherwin-Williams Co.; Frank X. Thompson, R. C. A.; Cornelius Reckers, Georgia-Pacific Plywood Co., Inc.; George Lennaeus, Southern Varnish Corp.

B. Exterior Finish—Natural Exterior Finish: Willard Pratt, California Redwood Assoc.; D. Countryman, Douglas Fir Plywood Assoc.; T. E. Werkema, Dow Chemical Co.; Don E. Laughnan, U. S. Forest Products Lab.; J. C. Sarvis, Western Pine Assoc.

Pigmented Exterior Finish: F. L. Browne, U. S. Forest Products Lab.; George G. Sward, National Paint, Varnish and Lacquer Mfrs. Assoc.; A. J. Wandersleben, United Cooperatives.

The following attended the Wood Finishing Committee meeting: W. B. Summers and D. L. Haner, The Carborundum Co.; D. G. Lubeck; A. V. Hooper, Forest Interiors Mfg. Co.; J. C. Sarvis, Western Pine Assoc.; J. W. Johnson, Oregon Forest Products Lab.; T. E. Werkema, Dow Chemical Co.; Roy Yerger, Wood-Metal Ind.; and Roy M. Carter, N. C. State College.

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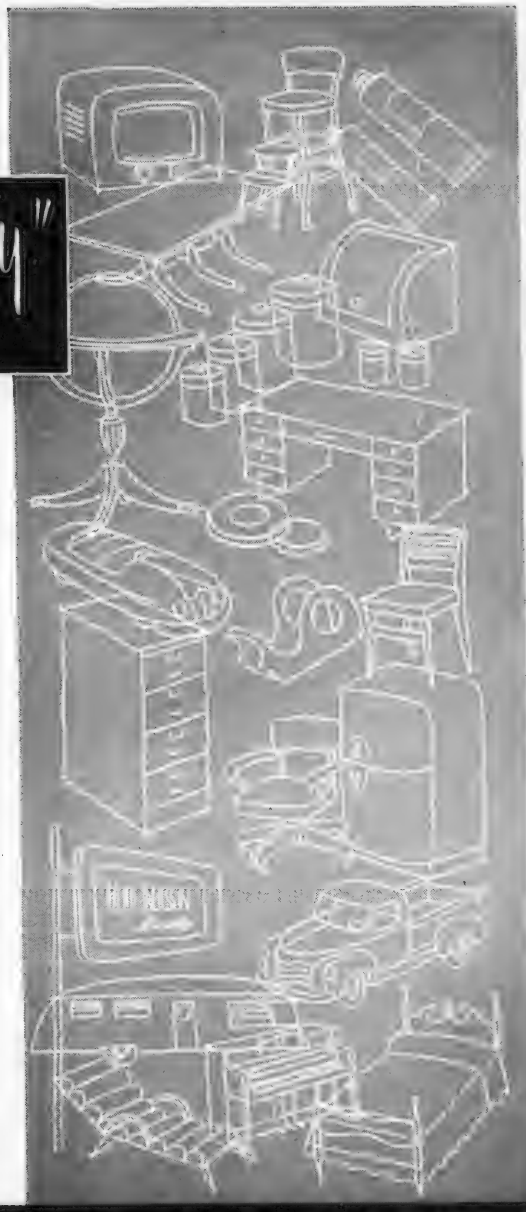

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WOOD PRESERVATION COMMITTEE
(left and above)

WOOD PRESERVATION — June 22—Acting Chairman, Ira Hatfield, Monsanto Chemical Co.

The meeting was called to order by Acting Chairman Ira Hatfield. In the absence of Secretary Mark M. Lehrbas, Gardner Garlick was appointed temporary secretary.

Mr. Hatfield stated that in order to intelligently discuss the annual report of the Committee, it might be well to again read the functions of the Wood Preservation Committee. This done, a 19-page report entitled "Advances in the Field of Wood Preservation in the United States in 1954–55" was distributed to the Committee members present, and time given for them to see it in its final draft form.

It was pointed out that the report in at least a measure did provide information to help "keep before the Forest Products Research Society developments in the field of wood preservation of interest to the Society." It was suggested that the report be made available to the Society in whatever way the Executive Board deemed best. (Note: This report will appear in the February 1956 Annual Review issue of the Journal.)

Following the reading of the report, it was brought out that the report dealt only with the preservation of wood as such, for the title and previous concept of the duties of the Committee had not encompassed the broader field of not only wood preservation, but of other related fields such as low and high density boards, chip and other types of board, and other cellulosic materials. It was unanimously agreed by those present that the scope of the Committee should be broadened by renaming it the "Wood and Wood Products Preservation Committee." Ralph Bescher agreed to bring this to the attention of the Executive Board, pointing out to them that such a broadening of scope would more nearly cover the interests of various industrial segments of the Society, and should also stimulate a greater interest in the Committee's work by drawing papers on subjects not now covered by the American Wood-Preservers' Association or other such groups.

It was moved by Charles Walters and seconded by George Olson, to have a technical session at the annual FPRS meeting to be held in Asheville in 1956. The motion was passed unanimously.

It was further suggested and agreed that the Committee should attempt to get papers for next year's meeting covering fire retardants, treating of ladders, treating of cooling towers, treating railroad car lumber, treating of plywood, treating of laminated timbers, treating of furniture and similar items to give dimension stability, and the treating of composition board.

The remainder of the meeting was spent discussing ways and means of improving the collection of information for the annual report, and on methods of getting more papers on wood and wood products preservation from members of the different Sections for the Journal.

Attending the Wood Preservation Committee meeting were: G. G. Garlick and H. A. Mahnke, Protection Products Manufacturing Co.; D. L. Kenaga and George E. Olson, Dow Chemical Co.; James C. Sarvis, Western Pine Assoc.; Alex J. Robinson, Great Northern Ry. Co.; P. B. Mayfield, Barrett Div., Allied Chemical & Dye Co.; A. R. Colman, Bell Telephone Company of Canada; R. H. Bescher, Koppers Company, Inc.; C. S. Walters, U. of Illinois; A. J. Loom, Northern Pacific Ry.; W. M. Conners, Vancouver Forest Products Lab.; Roy M. Carter, N. C. State College; Ira Hatfield and A. W. Hempelman, Monsanto Chemical Co.

QUALITY CONTROL—June 22—Chairman, C. S. Latimer, Nickey Brothers, Inc.

Chairman C. S. Latimer presided at the meeting and briefly reviewed the work done by the Committee. He announced that through correspondence and conversation, it was the feeling of the Committee Members that the scope of activity should be broadened. This broadening should take place in two directions: (1) the management and administrative phases of quality control, together with case histories, should be emphasized; (2) the use of statistical methods in the design and analysis of experiments should receive attention. Mr. Rietz commented that he felt that case histories of successful applications of statistical quality control installations should continue to be a major portion of the committee's work. Mr. Brice commented that he welcomed a place in FPRS where statistics in design of experiments with wood might be discussed. Mr. Ripley commented that examples of successful quality control programs, not necessarily statistical in nature, would be valuable contributions to the committee's work.

The chairman announced that the matter of a brochure on statistical quality control was still pending. Mr. Tombach agreed to assist on this project.

As previously agreed, the meeting was turned over to Mr. Ripley, who arranged for a brief program covering some quality control applications in the Northwest. Mr. Ripley introduced Mr. A. J. Golick. Mr. Golick gave a very clear presentation of the problems encountered in raising the quality level in a plant to a high, acceptable level. He covered problems in dealing with management, in administering a program, in setting up a trouble shooting and lot by lot tracing system, and in establishing practical means for maintaining quality. Mr. Golick used examples from his own experience at the Seattle Door Co. His presentation was well received, and it was suggested that Mr. Golick's presentation was the type of material that would be appropriate for a paper at a national meeting.

Mr. Ripley introduced Mr. Beckers of the Georgia-Pacific Plywood Co. Mr. Beckers described the problems of creating incentives among the employees to do good work and to work as a team. He described his own accomplishments in this field. Mr. Beckers displayed several posters which were prepared at his plant. The posters were cleverly drawn cartoons, illustrating means of maintaining good quality as well as some bad practices which should be avoided.

At an informal supplementary meeting, Dr. Ben Bryant, University of

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QUALITY CONTROL COMMITTEE

MARKETING COMMITTEE

Washington, gave a brief report of the status of quality control in the Northwest. Dr. Bryant said that most of the activity in quality control was in industries other than woodworking, but that interest in the subject in woodworking plants was increasing. He described several examples covering plywood, door, and chipcore plants.

It was decided to request that a technical session be devoted to quality control at the 1956 National Meeting in Asheville, N. C. It was decided that the size of the committee should be enlarged.

The meeting was then adjourned.

Attending the meeting were: Chairman, C. S. Latimer, Nickey Brothers, Inc.; Robert H. Ripley, Douglas Fir Plywood Assoc.; C. Beckers, Georgia-Pacific Plywood Co.; W. E. Pratt, California Redwood Assoc.; Dean C. Brice, Western Pine Assoc.; A. J. Golick, Seattle Door Co.; Raymond C. Rietz, U. S. Forest Products Lab.; James W. Johnson, Oregon Forest Products Lab.; Hugh A. Wilcox, Cascades Plywood Corp.; and Harold Tombach, Consultant.

MARKETING — June 22—Chairman, P. H. W. Creden, Edward Hines Lumber Co.

The meeting was called to order by Chairman P. H. W. Creden.

Topics discussed included:

I. A four-year college curriculum:

Such a curriculum should have required courses on physical and mechanical properties of wood and competing materials, such as aluminum, steel, brick, concrete, plastics. It should include courses in merchandising, involving transportation, distribution procedures and channels, salesmanship, psychology of human motivation, advertising, and sales management. Accounting, particularly applied to sales and manufacturing, is essential. A thorough knowledge of manufacturing, use, and construction details of building are further requirements.

Mr. Thomas mentioned that many schools are not adequately including this course material in their training. Others indicated the above subject matter and more was a part of the four-year college program. N. C. State College, Michigan State College, University of Minnesota, and the College of Forestry at Syracuse are the only four colleges on record that provide the type of training the group considered desirable.

II. Development of better educational presentations for thirty-day schools:

It was emphasized by Mr. Creden that sales and promotional features

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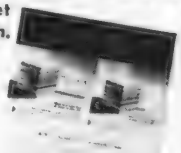

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should be omitted from the marketing short courses or institutes. Reference to trade name products should be omitted or minimized. Technical properties and information of value in making comparisons should be stressed. In some cases this can be most effectively done as discussion panels. Comparisons of lumber species were considered essential to point out various applications in which wood serves best. If a species, due to durability or strength, is more desirable in certain applications than another type of wood, those facts should be made known.

Suggestions for improving text material and material in the Dealer Operating Guide were considered necessary improvements.

Topics suggested for revision and presentation at the thirty-day schools from a practical layman's, user's, consumer's or do-it-yourself viewpoint were:

1. Glues and gluing.
2. How to make repeat sales.
3. How to treat, use, and handle treated lumber.
4. Laminated wood construction, properties, and use.
5. How to handle and merchandise lumber paneling.
6. Natural wood finishes and finishing.
7. Unsurpassed features of lumber for construction and appearance.

III. Forest products clinics for retail lumber dealer conventions:

The above topics, suggested in (II.), would form the basis of a number of clinics at retail lumber dealer association conventions in which outside speakers and members could participate.

This committee suggested presenting the idea at the August 15–18 meeting of the State and Regional Executive Secretaries of the Retail Lumber and Building Supply Dealers Associations in Chicago, Ill. The topics, source of speakers, organization, and arrangements would be the subjects to explain and offer for approval of the secretaries to incorporate into their meetings. This idea, to serve as a highlight of the dealer associations convention, may be presented under the auspices of this committee of the Forest Products Research Society. Chairman Creden was authorized to secure approval.

IV. Plans for 1956 meeting:

A technical session and committee meeting was the unanimous desire of the group. The need for an active committee on forest products marketing is necessary for the welfare and growth of the forest products industries. Greater knowledge of marketing techniques and procedures was discussed as the technical session theme for the 1956 annual meeting in Ashville, N. C.

Attending the meeting were: Chairman, P. H. W. Creden, Edward Hines Lumber Co.; John Reno, Pacific Lumber Co.; David P. Thomas, U. of Washington; R. W. Pettersen, St. Paul-Tacoma Lumber Co.; J. R. Pfeiffer, Oregon Forest Products Lab.; W. Bell, Western Retail Lumber Dealers Assoc.; L. R. Pugh, St. Maries Lumber Co.; and Secretary, Roy M. Carter, N. C. State College.

VENEER AND PLYWOOD—June 22—Chairman, H. O. Fleischer, U. S. Forest Products Laboratory

Presiding was the Committee Chairman, H. O. Fleischer. Mr. James Roberts recorded the minutes. The attendance was 30.

I. Committee organization:

It is anticipated that the committee organization and membership will remain substantially the same for the next year, with possible addition of members, particularly in the southeastern states because of the annual meeting in Asheville, N. C., in 1956.

II. Report on committee planning and functions:

Dr. James Bethel presented a report proposing several functions for committee activity. In addition to the assigned functions of planning technical sessions and preparing annual industry reports, it was suggested that the committee encourage research and development in the industry. It was proposed, for example, that the com-

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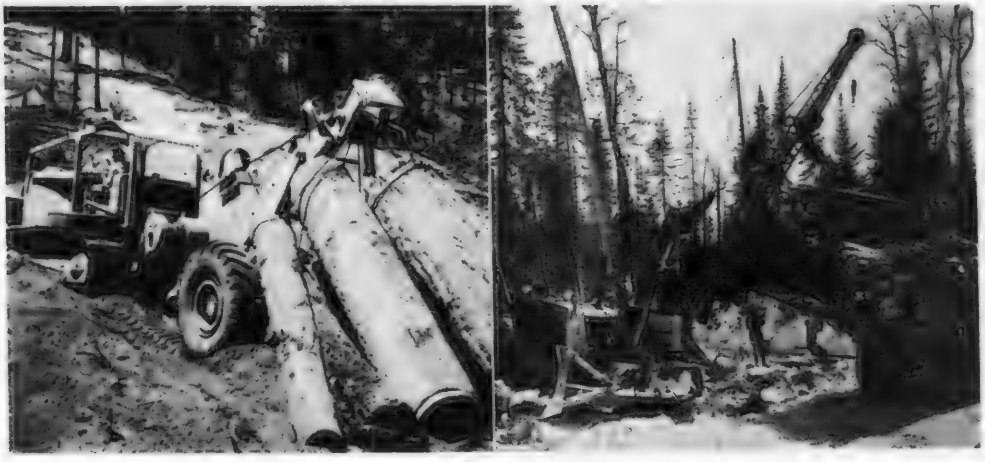

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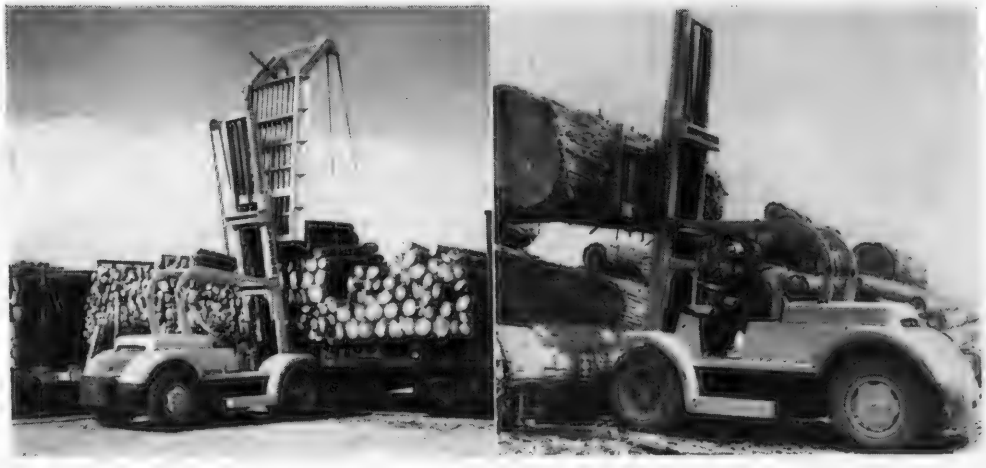

VENEER AND PLYWOOD COMMITTEE

PACKAGING COMMITTEE

mittee should encourage research in the following fields:

a. Study the precision of cutting on veneer lathes.

b. Study log heating practices in the hardwood plywood industry.

c. Study veneer drying schedules used in hardwood and softwood plywood industries.

d. Study log conservation methods, including procedures for minimizing loss due to end checking, stain, decay, mold and insect attack.

It was suggested that these studies could either be carried out as surveys, or assigned to individuals or organizations for detailed study.

Considerable discussion followed upon presentation of this report. The desirability of stimulating research of a fundamental nature that would be applicable to veneer and plywood production was stressed. It was thought that research organizations, universities, and individuals could be influenced in their choice of research projects if the needs of the industry were brought to their attention. With this in mind, it was decided that the committee should sponsor the preparation of a list of problems that confront the industry and should serve as a clearing house for bringing those who have problems into contact with those who may be in a position to supply or find the answers.

Specifically it was decided that a survey should be made by the committee, to form the basis for the final compilation. A preliminary sample questionnaire is first to be compiled, outlining the needs and asking for a listing of problems. This sample questionnaire is first to be submitted to any and all research agencies who might be interested, requesting: (1) their comments regarding the questionnaire, (2) reports of any work in the field now in progress, and (3) consideration of problems that might be undertaken by the organization in question within the next year, and that might be ready for reporting at the next annual meeting. After revision, the questionnaire will then be submitted generally to the industry. The committee, or a subcommittee thereof, is to have responsibility for screening replies to the questionnaire, for classifying all problems, and for preparing the final list for publication. The desirability for early action was stressed.

III. Section meetings:

It was agreed that the development of meetings on the Section level, dealing specifically or entirely with veneer and plywood, would be desirable. The committee should contact Section officers with the offer to sponsor a technical session on veneer and plywood on the regional basis. Sections should be encouraged, in the absence of a veneer and plywood session, to provide time for meetings of subject matter groups where those in a particular industry, such as veneer and plywood, can meet to discuss mutual problems.

IV. Veneer and plywood terminology:

The National Office of FPRS requested the committee to consider a request to set up a standard terminology for veneer and plywood products, processes, and the like. Mr. Northcott reported that the forestry agencies of the British Empire, under sponsorship of the Empire Forestry Association, are compiling terminology that would be applicable. It was decided to keep in touch with this development and, when that list becomes available, to suggest that it be publicized by FPRS.

V. Annual Industry Report:

The chairman reported that he felt that the next, or second, annual report on the status of the veneer and plywood industry should again be a general report following and expanding the outline established by the first annual report. In later years this pattern may be changed to stress only selected new developments.

VI. General Session at 1956 Annual Meeting:

The committee was unanimous in its feeling that a general session on veneer and plywood should be held at the 1956 meeting of FPRS in Asheville, N. C.

Attending the meeting were: Chairman, H. O. Fleischer, U. S. Forest Products Lab.; Recorder, J. R. Roberts, Weyerhaeuser Timber Co.; Ben S. Bryant, U. of Washington; R. W. Wellwood, U. of British Columbia; J. S. Bethel, N. C. State College; J. G. Bene, Western Plywood Co., Ltd.; D. Cullity, Westralian Plywoods Pty., Ltd.; Erkki Soivio, Finnish Plywood Institute; Phil Northcott, Vancouver Forest Products Lab.; F. C. Simmons, Northeastern Forest Experiment Station; F. J. Shelton, C. E. Laney, and R. K. Stensrud, Reichhold Chemical Co.; C. Fanus, Roseburg Lumber Co.; W. R. Smith, Southeastern Forest Experiment Station; J. O. Snodgrass, Oregon State College; W. E. Pratt, California Redwood Assn.; R. L. Hiller, American Cyanamid Co.; A. T. Walton, Simpson Logging Co.; R. A. Yerger, Wood Metal Ind., Inc.; D. K. Saunders, Saunders Bros. Co.; T. E. Batey, Jr., R. Raymond and R. H. Ripley, Douglas Fir Plywood Assn.; Jorg Bugge, T. D. Bennett Veneers; Edward Kirkpatrick, Corvallis Plywood Co.; and H. H. McGuane, C. P. I. Veneers.

PACKAGING — June 23 — Chairman, K. W. Kruger, U. S. Forest Products Laboratory

Chairman K. W. Kruger opened the meeting by reviewing past activities of the Subject Matter Committee on Packaging. This topic, and the nature of the past three technical sessions on packaging, were discussed at length. The comments presented below summarize the observations and opinions expressed by members and non-members of the Committee.

Although attendance at all technical sessions on packaging has been good, loss of half the audience was noted at the Seattle meeting. This may be regarded as an indication of: (1) improper selection of topics; (2) the elementary or general material presented in many papers; or (3) an outright criticism of the content and quality of papers. It was generally agreed that interest in packaging sessions is likely to diminish at forthcoming meetings should prevailing circumstances persist. Perhaps the holding of successive packaging sessions at widely separated locations (Memphis, Grand Rapids and Seattle) was the principal reason for good attendance to date.

Attendance at past meetings of the Subject Matter Committee on Packaging has also been good but failure of

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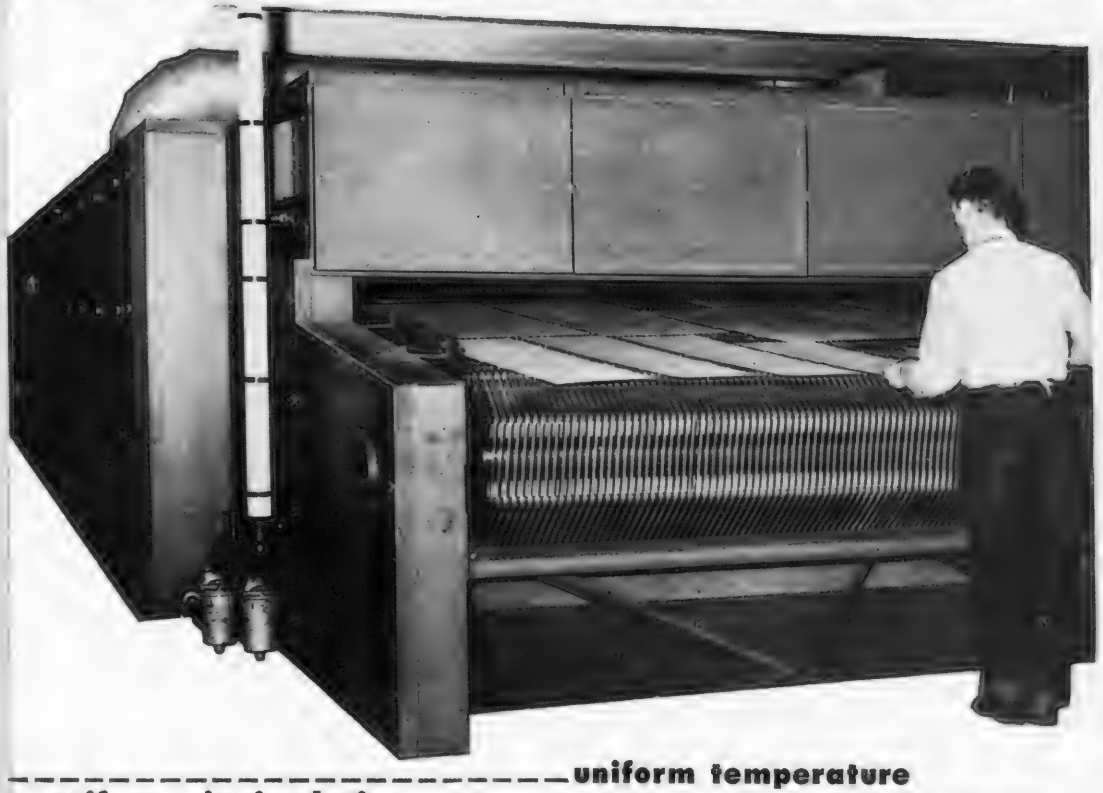

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WOOD DRYING COMMITTEE

COMPOSITION BOARD COMMITTEE

Committee members to attend this scheduled meeting was regarded by some of those who did come as a positive sign of waning interest in technical sessions on packaging as planned and conducted at the past three national meetings of the Society. This is no reflection on the activities of Committee Chairmen and certain Committee members who have been diligent in their contacts, planning, and arrangements involving programs and other matters. Yet it is obvious that many Committee members have not cooperated with their Chairman.

The ensuing discussion centered on the difficulties and questions outlined above. Conclusions and recommendations were as follows:

1. It was generally agreed that past technical sessions on packaging have not been effective in that the interest of F.P.R.S. members, the Committee, and others has not been sustained.

2. Agreement was unanimous for continuation of the Subject Matter Committee on Packaging. Continuity was regarded as an important factor in sustaining this segment of Society activity.

3. It was recommended that a request be made for a technical session on packaging at the Tenth National Meeting of the Society at Asheville, N. C.

4. Broadening of membership was recommended to include and represent additional divisions of the packaging industry, including paper, paperboard products, and packaging units of the aircraft industry.

5. Membership drives in each F.P.R.S. Section are suggested to recruit a variety of persons from the packaging industry.

6. It is strongly recommended that most topics for future packaging sessions be technical rather than general, and that particular care be taken to insure the selection of timely topics and the preparation of worthy papers to stimulate attendance and maintain the interest of all concerned.

7. The presentation of occasional papers on packaging topics at certain F.P.R.S. Section Meetings is considered to be desirable as a means for promoting sectional and national interest in the technical and practical aspects of packaging materials and methods.

8. The suggested theme for the Technical Session on Packaging at the Tenth National Meeting is "Paper and Paperboard Containers" because Asheville is reasonably close to many of the kraft and paperboard producers in the southern and southeastern states. Since three or four papers pertaining to the packing and packaging of furniture were presented at Grand Rapids two years ago, this subject was not considered to be an appropriate theme for the Asheville meeting.

9. Chairman Kruger suggested that co-chairmen be selected for future packaging sessions as a means for increasing the total Committee effort, which will be particularly important during the critical year ahead. Considerable effort will be necessary to revive interest in packaging and to insure the inclusion of packaging sessions at future national meetings.

10. Pending approval of the theme "Paper and Paperboard Containers" at the 1956 National Meeting of the Society, it is recommended that the Chairman or Co-chairmen of the Subject Matter Committee on Packaging be selected from the paper and paperboard industry.

Attending the meeting were: Chairman K. W. Kruger, U. S. Forest Products Lab.; Karl Bollerslev, Giustina Brothers Lumber Co.; J. W. Johnson, Oregon Forest Products Lab.; H. R. Welton, Northrup Aircraft, Inc.; A. R. Tegge, Quartermaster Container Labs.

WOOD DRYING—June 23—Chairman, L. D. Espenas, Oregon Forest Products Laboratory

Chairman L. D. Espenas opened the meeting and called for a report from Ray Rietz of the subcommittee investigating the seasoning lecture. Rietz reported that after due investigation, the subcommittee proposed that the scope of the lecture be broadened to include the entire forest products field and that the lecture be sponsored by the Society. A poll of the Wood Drying Committee was overwhelmingly in favor of this, and the proposal was presented to the National Board of the Society at their meeting in March 1955. The subject was to be brought up for further discussion at a meeting of the Subject Matter Committee Chairmen during the National Meeting in Seattle.

Mr. Carter remarked that a lecture of this type by a man of matured thought could contribute much to the Society. Mr. Pratt suggested that this be coordinated with the Forestry Historical Society with possible permanent recording.

Mr. Rietz reported on the status of the News Digest Publication, giving the subject matter breakdown and outlining possible papers that could be abstracted for the Digest. He cited the excellent report of the West Coast Dry Kiln Club annual meeting at Klamath Falls, Ore. A suggestion was made to punch standard 2-hole margin in the Digest to facilitate filing.

Mr. Pratt introduced a problem of public relations. Periodic proposals of so-called "new" processes which have previously been evaluated, good or bad, waste much time of the various authoritative sources, associations and laboratories. Mr. Engel suggested that a standard questionnaire be prepared for the promoter or inventor to fill out before interview. In this way, the new idea could be more readily evaluated. A motion was proposed by Mr. Carter and seconded to the effect that members of the committee inform the chairman concerning new ideas. These could then be evaluated and disseminated. Thus we would keep abreast of current ideas of much or little merit.

The Committee Annual Report was discussed. It will be comprised of a current seasoning bibliography published primarily to keep those informed who are not directly in the seasoning field. Mr. Espenas suggested that we increase committee membership in areas such as the deep South and other countries as well as through local kiln club officers.

A motion was advanced by Mr. Carter to have a technical session on seasoning at the next annual FPRS meeting in Asheville, N. C. This was seconded and possible topics were discussed. Mr. Pratt made a tentative offer to give a paper on moisture meters.

Mr. Holland of England commented on the various points brought out at the meeting. He gave a brief review of

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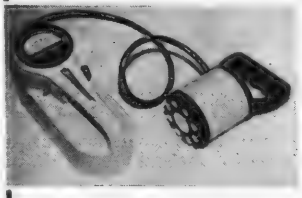

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CHEMICAL UTILIZATION COMMITTEE

the work he has been doing in radio-frequency drying.

Attending the meeting were: Chairman, L. D. Espenas, Acting Secretary, H. D. Stillwell, and J. Pfeiffer, Oregon Forest Products Lab.; R. C. Rietz, U. S. Forest Products Lab.; H. H. Smith, California Forest and Range Experiment Station; R. M. Carter, N. C. State College; W. E. Pratt, California Redwood Assoc.; J. D. Snodgrass, Oregon State College; R. G. Engel, Engel Lumber Co.; F. W. Holland, Consultant; Carl A. Rasmussen, Western Pine Assoc.; and W. C. Fountain, Vancouver Forest Products Lab.

CHEMICAL UTILIZATION—June 23—Chairman, Reavis C. Sproull, Herty Foundation Laboratory, Savannah, Ga.

The meeting was called to order by Chairman R. C. Sproull.

I. Review of Purpose of Committee:

After considerable discussion the purpose of the Committee was defined as follows:

The Committee would be concerned with the use of wood or wood residues wherever reactions take place which involve chemical changes by such methods as:

(a) extraction
(b) hydrolysis
(c) delignification
(d) pyrolysis
(e) fractionation
(f) irradiation
(g) microbiological modification

The definition includes the study of various subjects such as the chemistry of lignin, the chemistry of minor components of the tree, and the chemistry of wood liquors. It excludes the chemistry of purified cellulose as a part of the scope of the committee.

II. New Chemical Uses or Developments in the Field During the Last Two Years (Commercial and Academic):

A. Continual hammering away on lignin utilization—a broad but unspectacular advance.

B. Wax extraction of Douglas Fir bark by Kellogg Company—now in the market development stage.

C. Adhesive for plywood from paper plant wastes — By Dr. Borden Marshall, Ontario Research Foundation, Toronto, Canada.

III. Major Problems Involved in Extending the Chemical Utilization of Wood:

A. Comments by C. C. Heritage, Weyerhaeuser Timber Company, Tacoma, Washington.

1. From raw material standpoint, the use of sawdust is important.
2. From product standpoint, studies are needed on fractionation, pyrolysis, hydrolysis, and delignification.

B. Comments by E. G. Locke, Forest Products Laboratory, Madison, Wisconsin.

1. Must think toward using the whole wood for chemicals that can be obtained from it.

C. Comments by J. Mater, Mater Engineering, Corvallis, Oregon.

1. Must sell management and public on need of fundamental research. Good factual selling needed.

D. Other Comments.

1. Study of utilization of bark must be increased.

IV. Better Services on Part of Committee to Society and Public:

A. Information from other organizations and societies. A. S. Gregory, Development, Weyerhaeuser, suggested that Chemical Abstracts be approached for including a special section for Forest Products. After some discussion the chairman appointed a committee of E. G. Locke, A. S. Gregory, and J. D. Ross to explore the possibility with representatives of The American Chemical Society.

V. Program for Next Year—Annual Meeting 1956:

A. It was agreed to prepare a program for the next meeting.

B. Program Ideas:

1. Enzymatic separation of lignin—Nord of Fordham suggested for contact.
2. Extraction of useful products from wood.
3. Microbiological chemical changes in wood.
4. Bark uses.

VI. Survey Fields:

A. Pyrolysis: Chairman submitted a draft of a survey on the subject. J. D. Ross will bring it up-to-date and will submit as a review paper to the Journal.

B. Bark: Chairman submitted a draft of a bibliography survey on bark. W. G. Van Beckum will complete and submit as a review paper to the Journal.

C. Other Fields Suggested:

1. Lignin and delignification (Dr. Purves at Montreal).
2. Hemicellulose constituents.
3. Hydrogenation (F. P. L.).
4. Irradiation (J. Mater).
5. Extractives.

Above topics will be carried out by assignment when and where possible.

The meeting was summarized and the Chairman called for volunteers to sign with Secretary for work on the committee. The following signed: A. S. Gregory and J. Mater.

The meeting was adjourned by the Chairman after being accorded a vote of thanks and confidence for his work.

Attending the meeting were: D. L. Kenaga, The Dow Chemical Co.; Charles Schenker, Proctor and Gamble; A. S. Gregory, Weyerhaeuser Timber Co.; W. L. Shilling, Crown Zellerbach Corp.; Jean Mater, Mater Engineering; R. H. Creighton, Macmillan and Bloedel Ltd.; Daryl Ross and Harold Ely, Oregon Forest Products Lab.; E. T. Clapperton, Pope and Talbot; R. N. Hammond, Consultant; John Burns, Van Waters and Rogers; R. C. Phillips, Stanford Research Institute; C. Heritage, Weyerhaeuser Timber Co.; W. Van Beckum, Pacific Lumber Co.; L. R. Louis, Bramco, Inc.; R. Shreck, Union Lumber Co.; F. H. Kaufert, U. of Minnesota; E. G. Locke, U. S. Forest Products Lab.; K. G. Borchgrevink, Chapman Manufacturing Co.; H. D. Erickson, U. of Washington; R. Sproull, Herty Lab.; and Kenneth Chesley, Crossett Co.

EMPLOYMENT—June 20—Chairman, Newell A. Norton, Pennsylvania State University

The meeting was called to order by Chairman Norton. Attending were: Dr. Alexis J. Panshin, Ira Hatfield, Dr. Frank Kaufert, Dr. Ben Bryant, Harvey H. Smith, Dr. Eldon Behr and Bob Smith.

Size of present National Committee: It was decided that the six-man National Committee would be able to handle the work of the Employment Committee for 1955–56. It was suggested that in the future, Section Chairmen serving for three years should be appointed to serve under the Regional Chairman. The duties of these Section Chairmen were left open for later discussion.

Need for additional officers: As mentioned above, the committee believes it will be advisable in the future to set up Section Chairmen serving for three years. Also, Professor Norton, upon vote of the committee, will select a list of school professors who will handle employment correspondence for each of the forestry and wood technology schools on our list.

Need for Regional Committees: Regional committee members can appoint additional men if they feel it is advisable for them to do so; however, no official regional committees are planned for 1955–56.

Duties of Section Committees: It was decided that the following responsibility should be delegated to future section committees: compile company lists in each state, with names of the personnel officers of each of the companies.

Duties of FPRS representatives at colleges and universities: (a) Coordinate with regional men; (b) Compile lists of students seeking summer employment plus descriptions of their backgrounds; (c) It was suggested that the National Office send the summer student employment blanks on or about February 1 to each of the schools.

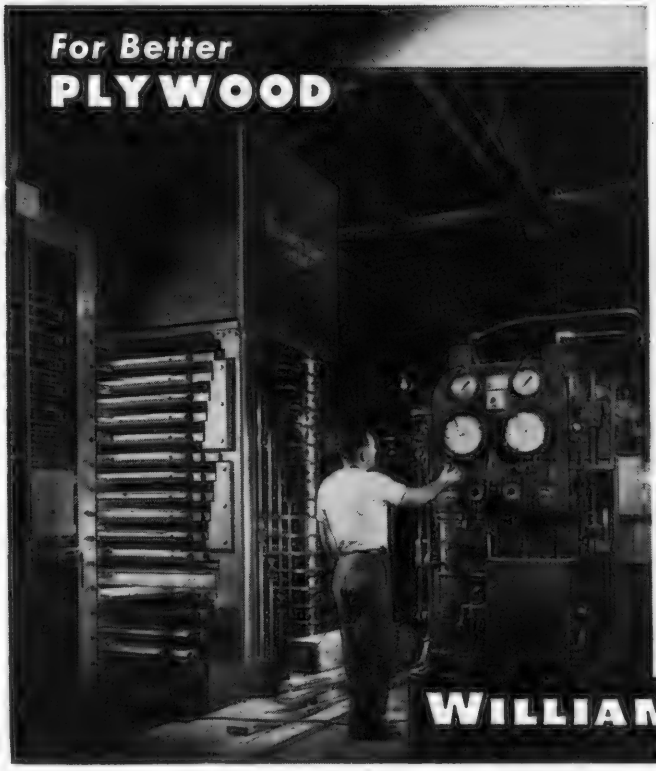
Student summer employment: (a) Dr. Norton will get a list of school professors who handle employment activities for each school; (b) Dr. Norton will direct a survey of wood employers in the United States who are willing to employ students during the summer; (c) It was decided that the employment committee should have the responsibility of informing industry personnel men of the type of students available during the summer from forestry and wood technology schools; (d) It was decided not to run ads in the News–Digest for students seeking summer jobs. The consensus was that the students should assume the responsibility for getting their own jobs. However, the list of employers plus names of personnel officers to write to should be furnished to the students by Dr. Norton's committee; (e) It was decided that summer employment of students is a school responsibility and not the responsibility of the FPRS Employment Committee or National Office. The Employment Committee will be glad to conduct a survey of employers who have summer jobs open for students. This survey list will then be forwarded to the employment committee school representative who will make the lists available to their particular students. The students will then take it upon themselves to correspond with prospective summer employers.

Cooperation with other placement services: We will be very glad to cooperate with other employment services. This cooperation may take the form of running ads for production and technical men seeking jobs through the FOREST PRODUCTS JOURNAL.

Publicity: (a) The FPRS Employment Committee and Education Committee will author a joint article describing the work of the Employment Committee and its objectives. Dr. Norton will coordinate with Dr. Panshin in writing this article, which it is hoped will appear in the JOURNAL and from which reprints can be later made for distribution to the wood industry.

Suggestions for the good of the cause: Many members agreed that the Employment Committee should conduct its affairs well in advance of the summer vacation so that students will receive the list of industry openings in sufficient time to be able to find early employment. It was suggested that the National Office write to each individual member and supporting member informing them that the FPRS has the Employment Service for college graduates seeking jobs and for employers looking for men; plus the suggestion that they avail themselves of this service.

The meeting adjourned at 10:15 p.m.



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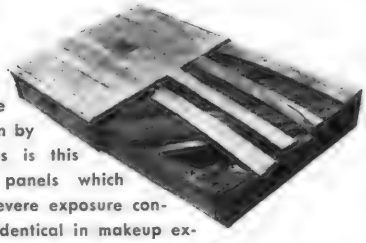

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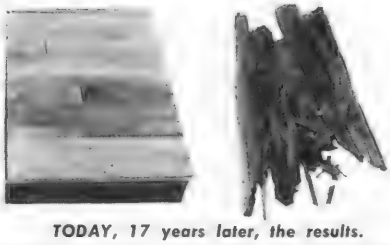

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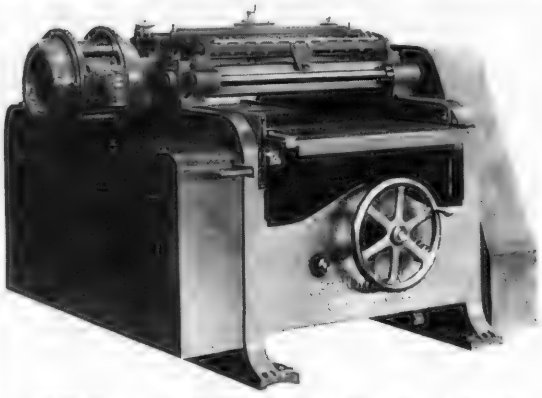

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Bibliography—Ben S. Bryant, College of Forestry, University of Washington, Seattle, Wash.

Technical Session 1956—D. B. Richards, Forestry Department, Alabama Polytechnic Inst., Auburn, Ala.

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Chairman—Fred C. Simmons, U.S.F.S., 102 Motors Ave., Upper Darby, Pa.

Logging Sub-Committee

Chairman—George Carr, Pacific Car and Foundry Co., Franklin Park, Ill.

J. A. Doyle, Forest Products Laboratory of Canada, Ottawa, Ont., Canada

R. O. Gustafson, Westvaco Experimental Forest, Georgetown, S. C.

Leland Hooker, Michigan College of Mining and Technology, Houghton, Mich.

Myron Krueger, University of California, Gianinni Hall, Berkeley, Calif.

Olin Lee, Euclid Division — General Motors Corps., 9203 N. E. 5th, Bellevue Wash.

Bruce Mety, Southern Lumber Co., Warren, Ark.

E. E. Matson, Pacific Northwest Forest Experiment Sta., Box 4059, Portland 8, Ore.

Sawmilling Sub-Committee

Chairman—Milton H. Mater, Mater Engineering, P.O. Box 236, Corvallis, Ore.

John Howe, Chadbourne Lbr. Co Bethel, Me.

Siegfried Tolle, Northeastern Forest Products, Pownal, Vt.

John Veach, Mgr., Bemis Hardwood Co., Robbinsville, N. C.

John Sims, W. T. Smith Lbr. Co., Chapman, Ala.

James O'Neil, University of Missouri, Springfield, Mo.

Richard M. Connor, Pres., Connor Lumber and Land Co., Laona, Wis.

J. E. Leuthold, Deer Park Pine Industries, Inc., Deer Park, Wash.

T. P. Gallagher, New Mexico Timber Co., Albuquerque, N. M.

Tom Shelton, Diamond Match Co., Chico, Calif.

Greg Lambert, California Redwood Assoc., Eureka, Calif.

Steve Batori, Guistina Bros., Eugene, Ore.

Jack Pfeiffer, Oregon Forest Products Lab., Corvallis, Ore.

Paul Heller, Pacific Pine Co. Ltd., New Westminister, B. C.

A. Norman, Nicola Valley Sawmills, Merrit, B. C.

G. E. Bell, Forest Products Lab. of Canada, Ottawa, Ontario

K. C. Compton, State U. College of Forestry, Syracuse, N. Y.

Ernest Clevenger, Corley Manufacturing Co., Chattanooga 1, Tenn.

Emanuel Fritz, 102 The Uplands, Berkeley 5, Calif.

D. P. Thomas, College of Forestry, University of Washington, Seattle. Wash.

MARKETING

Chairman—Philip H. W. Creden, Edward Hines Lumber Co., 77 West Washington St., Chicago 2, Ill.

Joseph R. Foley, Weyerhaeuser Timber Co., 2129 Daily News Bldg., Chicago 6, Ill.

John Reno, The Pacific Lumber Co., 35 East Wacker Dr., Chicago 1, Ill.

A. Fletcher Marsh, Marsh and Truman Lumber Co., 1463 McCormick Bldg., Chicago, Ill.

George W. Stanley, Jr., Solar-Sturges Manufacturing Div., Pressed Steel Car Co Melrose Park, Ill.

Robert L. Hiller, American Cyanamid Co., 3505 North Kimball, Chicago, Ill.

Howard E. Olson, Chapman Chemical Co., 3 Hunter Lane, St. Paul, Minn.

L. J. Fitzpatrick, J. J. Fitzpatrick Lumber Co., 3230 University Ave., Madison 5, Wis.

Arthur Lahey, Weyerhaeuser Sales Co. 2091 First National Bank Bldg., St. Paul 1 Minn.

F. C. SIMMONS

P. H. W. CREDEN

K. W. KRUGER

C. LATIMER

H. O. FLEISCHER

G. G. MARRA

Charles H. White, American Walnut Manufacturers' Assn., 666 Lake Shore Drive, Chicago, Ill.

PACKAGING

Chairman—K. W. Kruger, U. S. Forest Products Laboratory, Madison 5, Wis.

Joseph P. Foley, Weyerhaeuser Timber Co., 400 W. Madison St., Chicago 6, Ill.

A. R. Tegge, Jr., Quartermaster Food & Container Inst., 1819 W. Pershing Rd., Chicago 9, Ill.

Tom Munroe, Moraine Box Co., Dayton 1, Ohio.

Earl R. Stivers, Package Research Laboratory, Stapling Machines Co., Rockaway, N. J.

J. R. Watkins, P. O. Box 1341, New Haven, Conn.

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Karl Bollarslev, 2845 Elinor St., Eugene, Ore.

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James D. Studley, 604 Somerset Place, NW, Washington 11, D. C.

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Armin Elmendorf, Elmendorf Corp., 322 W. Washington St., Chicago 6, Ill.

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Fred E. Dickinson, Forest Products Laboratory, University of California, 1301 S. 46th St., Richmond 4, Calif.

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Paul H. McCormack, National Adhesives Co., 270 Madison Ave., New York 16, N. Y.

Thomas G. Gill, 509 N. Oxford St., Arlington, Va.

J. W. Johnson, Oregon Forest Products Laboratory, Corvallis, Ore.

F. D. Long, Container Corp. of America, 10 N. Clark St., Chicago 2, Ill.

QUALITY CONTROL

Chairman—Charles Latimer, Nickey Brothers, Inc., 2700 Summer Ave., Memphis 12, Tenn.

Cornelius Reckers, Georgia-Pacific Plywood Co., Olympia, Wash.

Willard E. Pratt, California Redwood Assoc., 576 Sacramento St., San Francisco 11, Calif.

Dean C. Brice, Western Pine Assoc., 510 Yeon Bldg., Portland, Ore.

A. J. Golick, Seattle Door Co., 11100 Roosevelt Way, Seattle 99, Wash.

Raymond C. Rietz, U. S. Forest Products Laboratory, Madison 5, Wis.

James W. Johnson, Oregon Forest Products Laboratory, Corvallis, Ore.

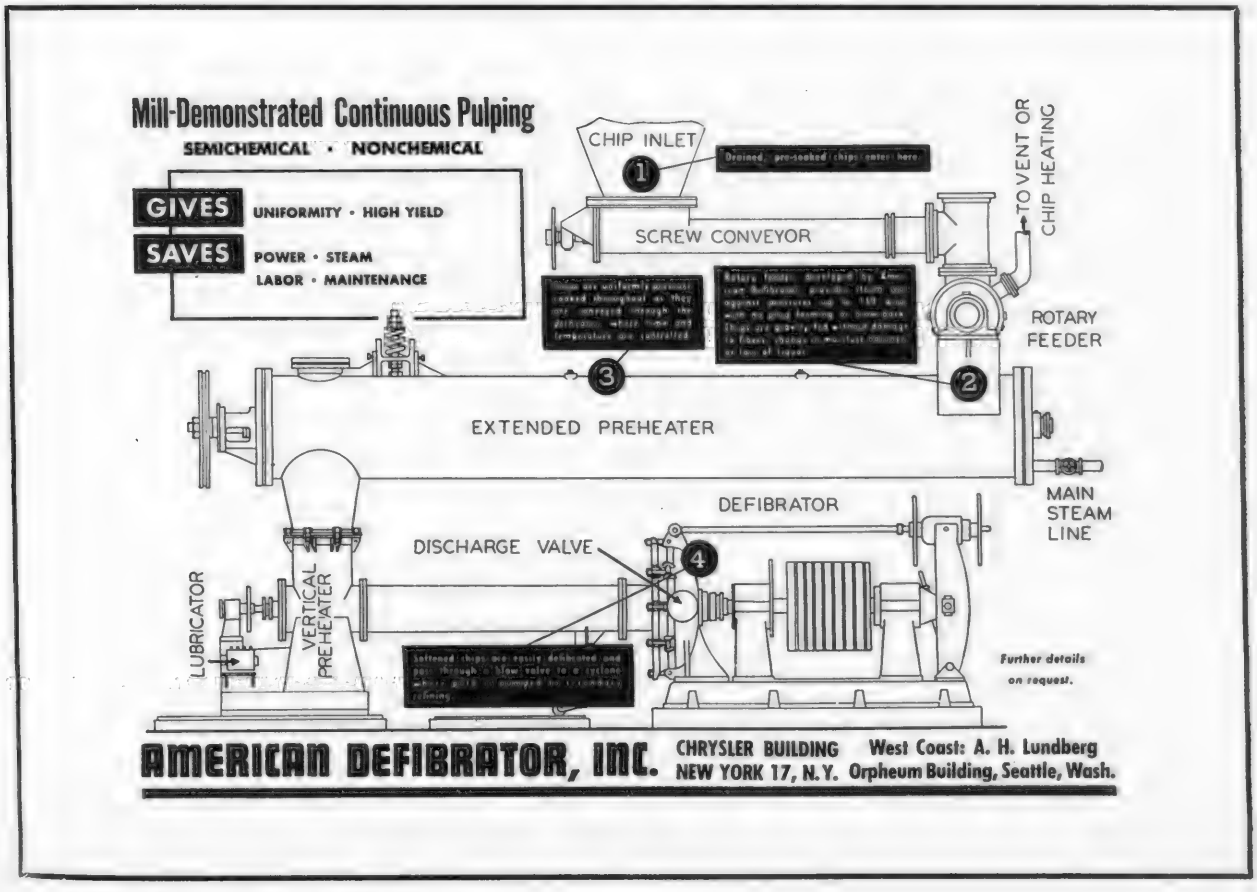
Hugh A. Wilcox, Cascades Plywood, Lebanon, Ore.

Harold Tombach, 2891 Canal Ave., Long Beach 10, Calif.

VENEER AND PLYWOOD

Chairman—H. O. Fleischer, Forest Products Laboratory, Madison 5, Wis.

John Bene, Western Plywood Co., Ltd., 900 E. Kent Ave., Vancouver 15, B. C., Canada.



L. D. ESPENAS

E. S. JOHNSON

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O. J. Bugge, 6820 N. E. Tillamook St., Portland 13, Ore.

John Butler, Hardwood Plywood Inst., 1012 Crescent Ave., N.E., Atlanta, Ga.

Moss B. Christian, Chicago Mill and Lumber Co., Tallulah, La.

Wayne F. Hutchins, American Seating Co., Ninth and Broadway, Grand Rapids 2, Mich.

Ericsson H. Merritt, Ericsson Merritt, Inc., 532 Pine St., Lockport, N. Y.

R. W. Peterson, Forest Products Laboratories, Ottawa, Ont., Canada.

John D. Ritchie, Douglas Fir Plywood Assoc., Tacoma 2, Wash.

James R. Roberts, Development Center, Weyerhaeuser Timber Co., Longview, Wash.

Russell Stadelman, Nickey Brothers, Inc., 2700 Summer Ave., Memphis 12, Tenn.

A. T. Walton, Simpson Logging Co., Shelton, Wash.

Charles H. White, American Walnut Manufacturers Assoc., 666 N. Lake Shore Drive, Chicago 11, Ill.

Boyd Witherow, Southeastern Forest Experiment Station, P. O. Box 2570, Asheville, N. C.

John J. Zirkle, Jr., Wood Products Branch, Bureau of the Census, Washington 25, D. C.

WOOD COMPOSITION BOARD

Chairman—George G. Marra, Washington State Institute of Technology, Pullman, Wash.

Wayne Lewis, U. S. Forest Products Laboratory, Madison 5, Wis.

F. F. Beil, Curtis Co., Inc., 114 Twelfth Ave., Clinton, Iowa.

H. C. L. Miller, Miller Hofft Inc., Richmond, Va.

J. B. Palmer, Masonite Corp., 111 West Washington St., Chicago, Ill.

Arthur L. Mottet, Long-Bell Lumber Co., Longview, Wash.

Thomas J. Martin, Monsanto Chemical Co., Springfield, Mass.

R. L. Campbell, American Manufacturing Co., Tacoma 2, Wash.

WOOD DRYING

Chairman—Leif D. Espenas, Oregon Forest Products Laboratory, Corvallis, Ore.

Raymond C. Rietz, U. S. Forest Products Laboratory, Madison, Wis.

Fred E. Dickinson, University of California, Forest Products Laboratory, 1301 South 46th St., Richmond 4, Calif.

William J. Delmhorst, Delmhorst Instrument Co., Boonton, N. J.

Victor H. Clausen, California Redwood Assoc., 521—3rd St., Eureka, Calif.

Pat Williams, Jr., Moore Dry Kiln Co., North Wilkesboro, N. C.

E. D. Marshall, 541 Humason Ave., Lufkin, Texas.

Harold Rhodes, J. W. Bolton & Sons, Lawrence, Mass.

Harold B. Gatslick, State University College of Forestry, Syracuse 10, N. Y.

F. W. Guernsey, Forest Products Laboratory, University of British Columbia, Vancouver, B. C., Canada.

H. J. M. Jorgensen III, Jorgensen-Bennett Mfg. Co., Box 4605 North Station, Memphis, Tenn.

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R. S. Millett, Forest Products Laboratories, Ottawa, Ont., Canada.

Harvey H. Smith, California Forest & Range Exp. Sta., P. O. Box 245, Berkeley 1, Calif.

WOOD FINISHING

Chairman—E. Sigurd Johnson, Industrial Engineering Dept., North Carolina State College, Box 5547, Raleigh, N. C.

Furniture and Interior Woodwork Subcommittee

Roy M. Carter, N. C. State College, Raleigh, N. C.

Donald G. Lubeck, Hammond Organ Co., 4922 Louise Ave., Skokie, Ill.

R. I. Quigley, The Lilly Co., High Point, N. C.

P. F. De Saix, Carborundum Co., Box 1574, High Point, N. C.

F. H. Thomas, Sherwin-Williams Co., 115th & Cottage Grove Ave., Chicago 28, Ill.

Frank X. Thompson, R. C. A., Finishes Div., Camden, N. J.

Cornelius Reckers, Georgia-Pacific Plywood Co., Inc., Olympia, Wash.

George Lennaeus, Southern Varnish Corp., P. O. Box 1004, Roanoke, Va.

Exterior Finish Subcommittee Natural Exterior Finish

Willard Pratt, California Redwood Assoc., 576 Sacramento St., San Francisco 11, Calif.

David Countryman, Douglas Fir Plywood Assoc., Tacoma Bldg., Tacoma, Wash.

T. E. Werkema, Dow Chemical Co., Midland, Mich.

Don E. Laughnan, U. S. Forest Products Lab., Madison, Wis.

James C. Sarvis, Western Pine Assoc., Research Laboratory, 7733 S. E. 13 Ave., Portland 2, Ore.

Pigmented Exterior Finish

F. L. Browne, U. S. Forest Products Lab., Madison, Wis.

George G. Sward, National Paint, Varnish & Lacquer, 1500 Rhode Island Ave., Washington, D. C.

A. J. Wandersleben, United Cooperatives, 2423 E. Main St., Alliance, Ohio.

WOOD MACHINING

Chairman—L. A. Patronsky, Wabash Screen Door Co., 2222 S. E. Elm St., Minneapolis, Minn.

L. H. Reineke, U. S. Forest Products Laboratory, Madison, Wis.

Norman C. Bye, Henry Disston & Sons, Inc., Unruh & Milnor Sts., Philadelphia 35, Pa.

George W. Stanley, 1436 Morgan Ave., La Grange Park, Ill.

Donald E. Flinchbaugh, York, Pa.

Russell Gray, G. M. Diehl Machine Works, 189 North Miami St., Wabash, Ind.

R. S. Crowder, Johnson-Crowder Co., 3906 N. 14 Ave., Birmingham, Ala.

R. D. Brooks, Yates–American Co., Beloit, Wis.

P. F. De Saix, Box 1574, High Point, N. C.

WOOD PRESERVATION

Chairman—Ira Hatfield, Monsanto Chemical Co., 800 N. Twelfth Blvd., St. Louis 1, Mo.

L. A. PATRONSKY

I. HATFIELD

Advances in Methodology of Applying Preservatives and Advances in Test Methods or Techniques

Pressure Field and Solvent Recovery:

M. S. Hudson, P. O. Box 2451, Spartanburg, S. C.

Pressure Field and Other Treating Methods:

J. A. Greenwald, Jr., Box 525, RFD 5, Tampa, Fla.

Other Than Pressure or Hot-cold Methods:

G. G. Garlick, Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

Conventional AWPA Methods:

P. B. Mayfield, Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y.

Test Methods for Preservatives:

Ralph Van Allen, Wood-Treating Chemicals Co., 5137 Southwest Ave., St. Louis, Mo.

New Chemicals Proposed for Wood Preservation or New Adaptations of Old Chemicals

J. O. Blew, U. S. Forest Products Lab., Madison 5, Wis.

F. J. Meyer, Dow Chemical Co., Midland, Mich.

R. A. Zabel, New York State College of Forestry, Syracuse 10, N. Y.

Wood Preservation Activities by Regions for 1955-56

Northeastern United States

H. W. Hicock, Conn. Agric. Exp. Sta., Box 1106, New Haven, Conn.

Mid-Continent

C. S. Walters, Forestry Department, Univ. of Illinois, Urbana, Ill.

E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3158, Memphis, Tenn.

South and Southeast

Mark Lehrbas, Southern Forest Exp. Sta., 2026 St. Charles Ave., New Orleans, La.

Walter Buehler, School of Forestry, Univ. of Florida, R.R. 1, Box 291, Lakeland, Fla.

Rocky Mountain and Inland Empire

L. A. Mueller, Rocky Mountain Forest Exp. Sta., Ft. Collins, Colo.

I. V. Anderson, Northern Rocky Mountain Forest Exp. Sta., Missoula, Mont.

Pacific Area

R. D. Graham, Oregon Forest Products Lab., 17th & May Sts., Corvallis, Ore.

Liaison-Association and Other Activities (AWPA, ASTM, etc.)

J. N. Roche, Tar Products Div., Koppers Company, Inc., 1200 Koppers Bldg., Pittsburgh 19, Pa.

Wood Products Preservation (Low Density Board, Hardboard, etc.)

G. G. Marra, Div. of Industrial Research, Wash. State Institute of Techn., Pullman, Wash.

FPRS Constitution and By-Laws

FPRS Constitution

Article I—Name

The name of the Society shall be the FOREST PRODUCTS RESEARCH SOCIETY.

Article II—Objectives

Section 1. The objectives of the Forest Products Research Society shall be to encourage and promote the efficient utilization of wood and other forest products in the broadest and most liberal manner, by

a. facilitating the interchange of information and ideas among individuals and organizations that are interested in forest products research, development, production, utilization, or distribution,
b. sponsoring meetings for the presentation and discussion of reports of investigations and experiences of its members and others,
c. publishing and distributing pertinent information,
d. promoting standard test methods and procedures,
e. encouraging acquaintanceships and cooperation among its members, and
f. carrying on related activities that further the objectives of the Society.

Section 2. The Society shall be operated on a non-profit basis as incorporated August 8, 1947, under the Articles of the General Not for Profit Corporation Act in the State of Illinois.

Article III—Composition of the Society

Section 1. The Society shall be composed of members who in turn shall be members of its local sections. It shall have an Executive Board, which, in addition to such duties as may be prescribed in this Constitution and by By-Laws of the Society, shall act as its administrative body.

Article IV—Membership

Section 1. The membership of the Society shall consist of the following classes or grades: Voting Members, Associate Members, Supporting Members, and Student Members.

Section 2. A voting member shall be an individual who is actively engaged in planning, supervising, or working in any phase of forest products research, development, production, utilization, or distribution.

Section 3. An associate member shall be an individual who is interested in forest products research, development, production, utilization, or distribution, although not actively engaged in such pursuits.

Section 4. A supporting member shall be an individual or organization who endorses the policies and activities of the Society and financially assists the Society by paying supporting membership dues as set forth in the Constitution.

Section 5. A student member shall be a bona-fide matriculated undergraduate or graduate student in a recognized college, university or scientific school.

Section 6. Voting members only shall be entitled to vote and to hold office, except that a supporting member may designate one representative who shall have all rights and privileges of a voting member. Such designated representative is herein referred to as a voting member. Associate members are entitled to all the privileges of membership except voting and holding office. Student members are entitled to the privileges of membership as set forth in the By-Laws.

Section 7. Applicants for membership shall be acted upon as provided in the By-Laws.

Section 8. Any member may resign by filing a written resignation with the executive secretary, but such resignation shall not relieve the member so resigning of the obligation to pay any dues theretofore accrued and unpaid.

Section 9. Any member who has resigned in good standing may be reinstated upon application and payment of prescribed current dues.

Section 10. The Executive Board by affirmative vote of two-thirds of all of the members of the Board may suspend or expel a member or remove from office any elected or appointed official for improper conduct. No person shall be expelled or removed from office except at a regular or special meeting of the Executive Board and then only after he shall have been given an opportunity to be heard in his own defense at the meeting.

Section 11. The termination of the membership of any member who is in default in the payment of dues shall be as provided in the By-Laws.

Article V—Finances

Section 1. Each member of the Society shall pay dues as provided in Sections 3, 4 and 5.

Section 2. The fiscal year shall begin on January 1 and shall terminate on December 31 of the same calendar year.

Section 3. Dues for voting and associate members shall be $15.00 per year, $2.00 of which will be returned to Sections to help defray administrative expenses. Annual dues for the fiscal year will be due and payable on or before *January 1* of each year. Voting, associate, and student members joining up to and including *December 31* shall receive all back publications to which they are entitled for that fiscal year.

Section 4. The annual dues for supporting members shall be $100.00 per year. Supporting members shall be elected to membership as of the first day of the month following their application and their renewal date shall be twelve months from this date. They will be entitled to all publications of the Society which are distributed while they are members regardless of the fiscal year of the Society.

Section 5. The annual dues for student members shall be $3.00 per year.

Article VI—Executive Officers

Section 1. The Executive Officers of the Society shall be the president, president-elect, vice-president and executive secretary.

Section 2. The duties of the president, president-elect, vice-president, and secretary shall be such as usually pertain to the offices they hold and also such other duties as may be delegated by the Executive Board or herein prescribed.

Section 3. The president-elect and vice-president shall be elected for one year by letter ballot and shall hold office for one year or until their successors qualify.

Section 4. The president-elect shall automatically become president at the expiration of his term of office and shall hold office for one year or until his successor qualifies.

Section 5. The executive secretary shall be appointed for one year by the Executive Board.

Section 6. In the event of a vacancy in the office of president, the unexpired term of this office shall be filled by the president-elect.

Section 7. In the event of a vacancy in the office of president-elect, the unexpired term of this office shall be filled by the vice-president.

Article VII—Executive Board

Section 1. The Executive Board shall consist of the president, president-elect, vice-president, immediate past president, and six regional board members, one elected from each of the six geographical regions, as such regions are defined in the By-Laws.

Section 2. The president and the executive secretary of the Society shall be the president and secretary of the Executive Board and the president shall serve as the presiding officer of that Board, but shall have no vote during meetings of the Board except that in case of a tie vote of the members present at a meeting, the president may cast the deciding vote.

Section 3. The Executive Board shall manage the affairs of the Society and shall have full power to control and regulate all matters not otherwise provided for in this Constitution.

Section 4. Two regional board members shall be elected each year at the annual election to serve on the Executive Board for a period of three years. Any vacancies occurring in the unexpired terms of regional board members shall also be filled at the annual election. In these cases, the elected officers shall serve only for the unexpired term.

Section 5. Five members of the Executive Board shall constitute a quorum for the transaction of business at any meeting of the Board, provided, that if less than five Board members are present at said meeting, a majority of the Board present may adjourn the meeting from time to time without further notice.

Section 6. A regular annual meeting of the Executive Board shall be held without other notice at the time of the annual meeting of members. The Executive Board may provide by resolution the time or place, either within or without the State of Illinois, for the holding of additional regular meetings of the Board without notice other than such resolution.

Section 7. The Executive Board by resolution adopted by a majority of the Board members in office may designate one or more Executive committees, each of which shall consist of the president and two or more other Board members, which committees to the extent provided in said resolutions shall have and exercise the authority of the Executive Board in the management of the Society; but the designation of such committees and the delegation thereto of authority shall not operate to relieve the Executive Board or any individual of any responsibility imposed upon him by law.

Section 8. In the event of an emergency, the president may act upon matters of management by mail or telegraph with members of the Executive Board. Questions must be submitted so that a board member may vote as affirmative, negative, or not voting. Receipt of at least five affirmative or five negative votes shall be necessary before action can be taken. A report of each such vote shall be transmitted within a reason-

able period of time to each member of the Executive Board.

Section 9. The Executive Board may fill any vacancy in the elective or appointive offices of the Society not otherwise provided for in this Constitution. Such Executive Board appointees to elective office shall serve only until the office can be filled by the next annual election.

Section 10. The Executive Board may also authorize the appointment of such other staff employees as may be required to render service to the members consistent with Society policies.

Article VIII—Nominations and Elections

Section 1. The National Nominating Committee is to be composed of the two immediate past presidents not serving on the Executive Board and four voting members who are not officers or board members and who are elected by the members of the Society at each annual meeting. The president is to designate one member to serve as chairman.

Section 2. The National Nominating Committee shall nominate at least one eligible member for the office of president-elect; at least one eligible member for the office of vice-president; and at least eight eligible members for the Nominating Committee.

Section 3. A Regional Nominating Committee shall be appointed by the president not later than six months after each annual meeting for each Region for which a board member is to be elected at the succeeding annual meeting. Before appointing the Regional Nominating Committee, the president shall request recommendations from the chairman or chairmen of the local section or sections in the Region. Each Regional Nominating Committee shall consist of five voting members who are not members of the Executive Board or section officers. The president is to designate one member to serve as chairman.

Section 4. Each Regional Nominating Committee shall nominate at least one eligible member from its region as defined in the By-Laws for the office of Regional Board Member.

Section 5. The nominating committees shall obtain written consent from each nominee before submitting his name to the executive secretary. The list of the nominees shall be sent to the executive secretary not later than ninety days preceding the next annual meeting and any vacancies in the list shall be filled by nominees selected by the Executive Board. All nominations shall be announced immediately to the membership at large.

Section 6. Voting shall not be restricted to the names submitted by the nominating committees. Any twenty-five voting members in good standing may file with the executive secretary, within 30 days after notification of the action of the nominating commitees, the name of an eligible candidate for any elective office, for which they are entitled to vote. If written consent is obtained from the nominee the name of such candidate shall be placed on the ballot. Furthermore, any voting member may vote for any eligible member of his own choice for any elective office by inserting the member's name on the ballot.

Section 7. All voting members of the Society in good standing shall be entitled to vote for president-elect, vice-president, and nominating committee members. The voting membership residing in each region as defined in the By-Laws shall elect its Executive Board member. The ballot shall clearly indicate the nominees for whom the members in the respective regions are entitled to vote. The ballot must contain the names of all nominees for each office arranged alphabetically and followed by a line on which the voter may write the name of an eligible nominee of his own choice. The ballots, with envelopes for secret voting, shall be placed in the mails to each member entitled to vote not later than twenty days before the annual meeting.

Section 8. Ballots shall be sealed and sent or delivered to the executive secretary before the polls close. The envelope shall be signed by the voter who shall also give his address as listed on the Society records.

Section 9. The polls shall be closed at noon of the first day of the annual meeting and the votes shall be counted by five members of any grade appointed as tellers by the presiding officer at the annual meeting.

Section 10. The persons who receive the highest number of votes for president-elect, vice-president and Regional Board member and the four persons receiving the highest number of votes for the office of Nominating Committee shall be declared elected provided that no one person may be elected to more than one office. In the event of a tie between candidates for the same office, announcement of the fact shall be made to the assembly immediately, and the voting members present at the closing session of the annual meeting shall elect the officer from the candidates so tied. The presiding officer shall announce to the meeting the names of the officers so elected.

Section 11. In the event no annual meeting of the Society is held, the officers shall be elected as provided for in the By-Laws.

Article IX—Meetings

Section 1. An annual meeting of the members shall be held on one or more successive days as near as practical to the start of the fiscal year for the purpose of electing officers and members of the regional board as are then to be elected and for the transaction of such other business as may come before the meeting.

Section 2. Special meetings of the members may be called either by the Executive Board or by not less than 10% of the members having voting rights.

Section 3. The Executive Board may designate any place as the place of meeting for an annual meeting or for any special meeting.

Section 4. Written or printed notice stating the place, day and hour of any meeting of members shall be delivered, either personally or by mail, to each member entitled to vote at such meetings, not less than ten days before the date of such meeting. In case of a special meeting or when required by statute or by the Constitution or By-Laws, the purpose for which the meeting is called shall be stated in the notice.

Section 5. Fifty voting members present at any annual or special meeting of the Society shall constitute a quorum. If a quorum is not present at any meeting of the members, a majority of the members present may adjourn the meeting from time to time without further notice.

Section 6. The order of business of meetings of the Society shall be arranged by the president, subject to additions or changes by the votes of a majority of the voting members present and voting.

Article X—Local Sections

Section 1. Local sections of the Society may be authorized by the Executive Board as provided in the By-Laws.

Section 2. Each section shall have as section officers at least a chairman, and a secretary who shall keep the Executive Board informed of Section activities.

Section 3. Any section may, subject to the approval of the Executive Board, adopt for its own government such By-Laws as may be necessary, provided that no part of these By-Laws shall conflict with the Articles of the Association, Constitution or By-Laws of the Society.

Section 4. Every member of the Society in good standing is automatically entitled to membership in that section in which his address on the records of the National Society will place him. This membership as so indicated by his record shall determine the region in which he is entitled to cast his vote for a regional Executive Board member. Any member may affiliate with other sections if he so desires or attend any section meetings on the same basis as members of the section, but his dues, as collected by the national executive secretary, and his voting privileges cannot be transferred except by change in address.

Section 5. The Executive Board shall have the right at any time to revoke the authorization of any Section and to terminate its existence. A Section whose authorization has been revoked by the Executive Board shall have the right to appeal its case to the Society, at any regular or special meeting of the members.

Article XI—Committees

Section 1. The Executive Board may authorize committees to serve the Society's interests.

Article XII—Publications

Section 1. The Society shall issue or sponsor such publications as in the judgment of the Executive Board will best carry out the Society's objectives.

Section 2. Publications of the Society shall be made available to all members not in arrears under such conditions as the By-Laws and the regulations of the Executive Board provide. Publications of the Society may also be made available to non-members under such conditions as the By-Laws and the regulations of the Executive Board shall provide.

Article XIII—By-Laws

Section 1. The Executive Board is empowered to adopt, amend and repeal By-Laws for the proper government of the affairs of the Society provided that nothing in the By-Laws shall conflict with this Constitution.

Section 2. Notice of proposed changes in By-Laws shall be given to each member of the Executive Board in the call for the meeting at which such changes are to be voted upon.

Article XIV—Amendments

Section 1. Any proposal to amend this Constitution shall be made by twenty-five or more voting members in good standing or by action of the Executive Board.

Section 2. All such proposals to amend the Constitution shall be submitted in writing to the executive secretary of the Society at least sixty days before the meeting of the Society at which the proposal is to be presented for action.

Section 3. A copy of every proposal to amend the Constitution shall be mailed by the executive secretary to each voting member in the Society in good standing at least thirty days before the regular or special

SOUTHLAND PAPER MILLS, INC.

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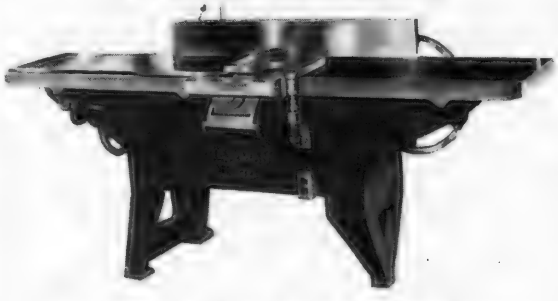
THE NEWMAN No. J-60 HAND JOINTER



The Newman No. J-60 Ball Bearing Hand Jointer is indispensable in any woodworking plant, large or small. For jointing and planing straight and out of line material, rabbetting, squaring, beveling, molding, beading, grooving etc., the No. J-60 is unexcelled. Tables are 8 feet long adjusting laterally to give a maximum opening of 10" at cutterhead and a minimum opening of 1¾". Cylinder is forged from high carbon machine steel, accurately ground and dynetrically balanced and is mounted in Precision Type Ball Bearings. The Newman No. J-60 can be adapted for high frequency operation, at any speed up to 7,200 R.P.M.

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GREENSBORO NORTH CAROLINA U. S. A.

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Wood and Lumber Dryer

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PEMCO MFG. CO. Mechanic Falls, Me.	4 Dryalators
J. C. ADAMS Jacksonville, Vt.	3 Dryalators
JAMESTOWN LOUNGE CO. Jamestown, N. Y.	1 Dryalator

LITERATURE ON REQUEST

LUMBER DRYALATORS, INC.

31 Milk Street Boston, Massachusetts

meeting at which it is to be presented for action.

Section 4. A proposal to amend the Constitution duly made as herein provided shall be presented to the next regular or special meeting of the Society. If the proposed amendment is approved by the majority vote of the members present, it shall be submitted by letter ballot to the voting members of the Society for ratification.

Section 5. The letter ballot shall be valid only if received within thirty days from the date of mailing and the ballots shall not be counted until thirty-one days have elapsed from the date of the original mailing of the ballots.

Section 6. Approval of two-thirds of the valid votes shall constitute ratification provided that at least fifty valid ballots are returned. The votes shall be counted by five members appointed as tellers by the president.

Article XV—Adoption

This Constitution shall be adopted and in force after ratification by the procedure provided for amendments in Article XIV. Upon ratification, the first vice-president shall become the president-elect, the second vice-president shall become the vice-president, and the nominating committee shall be elected by a mail ballot. Nominations for the nominating committee shall be made by a special nominating committee appointed by the president.

FPRS By-Laws

Article I—Membership

Section 1. Applicants for membership in the Forest Products Research Society shall fill out and send to the executive secretary the application form provided for that purpose, along with the necessary dues for the current fiscal year of the Society. The applicants shall indicate the desired class of membership on the application blank. The executive secretary is authorized to accept applications for membership from all known, responsible individuals and organizations. In case of any question, the application is to be referred to the Executive Board before any action is taken. All dues submitted with application blanks shall be returned to applicants who are not accepted by the Society.

Section 2. A student member shall attach to his application blank and subsequent renewals a letter from the head of the department in which he is majoring certifying that he is a bonafide, matriculated student.

Article II—Finances

Section 1. Any voting, associate or student member whose renewal dues are unpaid as of October 1 shall be automatically dropped from the rolls of the Society. The executive secretary will notify him of the termination of his membership and the reason therefor.

Section 2. Any member whose membership shall be cancelled for the non-payment of dues shall be eligible for reinstatement by paying the Society the cost of any publications he may have received during this six-months period of grace. The executive secretary is authorized to make a suitable adjustment in each individual case.

Article III—Officers

Section 1. If for any reason the election of officers shall not be held at a regular meeting of the Society, such elections shall be held as near the end of the fiscal year as convenient. Vacancies may be filled or new offices created and filled at any meeting of the Executive Board. All appointees of the Executive Board to elective offices shall hold office until their successors shall have been duly elected by the members and shall have qualified.

Section 2. The president shall be the principal executive officer of the Society. He shall preside at all meetings of the members and of the Executive Board. He may sign with the executive secretary or any other proper officer of the Society authorized by the Executive Board any deeds, mortgages, bonds, contracts, or other instruments which the Executive Board has authorized to be executed, except in cases where signing and execution thereof shall be expressly delegated by the Executive Board or by the Constitution or By-Laws or by statute to some other officer or agent of the Society; and in general shall perform all duties incident to the office of president and such other duties as may be prescribed by the Executive Board from time to time.

Section 3. In the absence of the president or in the event of his inability or refusal to act the Executive Board may authorize the president-elect, vice-president, or a Board member, in the order given, to perform the duties of the president, and when so acting, he shall have all the power of and be subject to all the restrictions upon the president.

Section 4. The executive secretary shall give a bond for the faithful discharge of his duties in such sum with such surety or sureties as the Executive Board shall determine. The cost of such bond will be at the expense of the Society. He shall have charge and custody of and be responsible for all funds and securities of the Society, receive and give receipts for money due and payable to the Society from any source whatsoever, and deposit all such moneys in the name of the Society in such banks, trust companies or other depositories as shall be selected by the Executive Board. This officer shall keep the minutes of the meeting of the members or the Executive Board in one or more books provided for that purpose; see that all notices are duly given in accordance with the provisions of the By-Laws or as required by law; be custodian of the corporate records and of the seal of the Society and see that the seal of the Society is affixed to all documents, the execution of which on behalf of the Society under its seal is duly authorized in accordance with the provisions of these By-Laws; keep a register of the post office address of each member as furnished by such members; and in general perform all duties incident to the office of executive secretary and such other duties as from time to time may be assigned to him by the president or by the Executive Board.

Section 5. The Executive Board may elect or appoint such other officers, including one or more assistant secretaries or one or more assistant treasurers as it shall deem desirable. If required by the Executive Board, the assistant treasurers shall give bonds for the faithful discharge of their duties in such sums and with surety or sureties as the Executive Board shall determine. The assistant treasurers and assistant secretaries shall perform such duties as shall be assigned to them by the executive secretary or by the president or by the Executive Board.

Section 6. The president-elect, vice-president, regional Executive Board members and elected members of the National Nominating Committee shall be ineligible for re-election to the same office for three years after the expiration of their respective terms.

Section 7. Any officer or agent elected or appointed by the Executive Board may be removed by the Executive Board whenever in its judgment the best interests of the Society would be served thereby, but such removal shall be without prejudice to the contract rights, if any, of the person so removed.

Section 8. The Executive Board may authorize any officer or officers, agent or agents, of the Society in addition to the officers so authorized in this Constitution and By-Laws to enter into any contract or to execute and deliver any instrument in the name of or in behalf of the Society and such authority may be general or confined to specific instances.

Article IV—Executive Board

Section 1. Special meetings of the Executive Board may be called by or at the request of the president or any five board members. The person or persons authorized to call special meetings of the board may fix any place, either within or without the State of Illinois, as the place for holding any special meeting of the Board called by them.

Section 2. Notice of any special meeting of the Executive Board shall be given at least ten days previously thereto by written notice delivered personally or sent by mail or telegram to each director at his address as shown by the records of the Society. Neither the business to be transacted nor the purpose of any regular or special meeting of the Board need be specified in the notice of such meetings unless specifically required by law or by the Constitution or the By-Laws.

Section 3. At the Executive Board meeting held at the time of the annual meeting the newly elected officers shall not take office until such time as the retiring president has finished old business and turned the office over to the new president, but this transfer of office must occur prior to the close of that meeting of the Executive Board.

Section 4. The Executive Board shall manage the affairs of the Society and shall have full power to control and regulate all matters not otherwise provided for in the Constitution and By-Laws. It shall make appropriations for specific purposes, direct the care of surplus funds of the Society, audit the accounts of the executive secretary, and publish the reports and proceedings of the Society.

Section 5. The act of the majority of the Executive Board members present at a meeting at which a quorum is present shall be the act of the Executive Board, except when otherwise provided by laws or by these By-Laws.

Section 6. The Executive Board may withhold from publications by the Society in whole or in part discussions, papers, or reports, the propriety, quality, or soundness of which is considered questionable.

Section 7. Executive Board members shall not receive any salaries for their services on the Board, but by resolution of the Executive Board, a fixed sum and expenses of attendance, if any, may be allowed for attendance at each regular or special meeting of the Board; provided that nothing therein contained shall be construed to preclude any board member from serving the Society in any other capacity and receiving compensation therefor.

Section 8. The Executive Board may accept on behalf of the Society any contributions, gift, bequest, or device, for the

general purposes or for any special purpose of the Society.

Article V—Resolutions

Section 1. All resolutions to be presented for a vote of the members at any regular or special meeting of the members shall be first passed upon by the Executive Board or by its duly authorized officer or committee

Article VI—Regions

Section 1. The regions of the Society shall be defined as follows:

Northwest Region. Alaska, Idaho, Montana, Oregon, Washington, Wyoming, and adjacent Canada.

Northeast Region. Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and adjacent Canada.

North-Central Region. Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and adjacent Canada.

South-Central Region. Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee and Texas.

Southwest Region. Arizona, California, Colorado, Nevada, New Mexico and Utah.

Southeast Region. Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia and West Virginia.

Section 2. The terms of regional board members shall begin at the close of the annual meeting at which they are elected by the voting members of that region, and shall continue through the next three annual meetings. Each of the regions designated shall be represented by one Executive Board member: to be elected as designated in the Constitution.

Section 3. Only voting members residing in a designated region shall be qualified for regional board member of that region.

Article VII—Local Sections

Section 1. Local Sections of the Society may be authorized by the Executive Board upon written petition of twenty-five (25) or more Voting Members residing in a geographic area as defined by the Executive Board.

Section 2. Local Section members shall be members of the National Society.

Section 3. A local section shall hold at least one meeting each year in order to retain its authorization.

Section 4. The section secretary shall transmit one copy of each paper presented at Section meetings to the executive secretary.

Article VIII—Committees

Section 1. The duly elected chairman and secretary of the local sections shall constitute a National Advisory Committee.

Section 2. The National Advisory Committee and the Executive Board shall meet together at the time of the annual meeting of the Society. The function of this Committee and of this meeting shall be to maintain close liaison between the local section and the Executive Board for the purpose of coordinating policies, needs and developments between local sections and between sections and the Executive Board.

Section 3. The President shall appoint a chairman of the National Advisory Committee at least 60 days prior to the Annual Meeting and notify the committee members.

Article IX—Offices

Section 1. The Society shall have and continuously maintain in the State of Illinois a registered office and a registered agent whose office is identical with such registered office, and may have other offices within or without the State of Illinois as the Executive Board may from time to time determine.

Section 2. The address of the registered office is Room 2034, 332 South Michigan Avenue, Chicago 4, Illinois, and the address of the Society headquarters is Box 2010, University Station, Madison 5, Wisconsin.

Article IX—Amendments

Section 1. These By-Laws may be altered, amended, or repealed, or new By-Laws may be adopted by a majority of the Executive Board present at any regular meeting or at any special meeting at which a quorum is present, provided that at least ten days written notice is given of intention to alter, amend, or repeal, or to adopt new By-Laws at such meeting.

Section 2. At the discretion of the Execution Board a vote on amendments to the By-Laws may be taken by letter ballot of the Society members provided that the proposed amendments have been approved by a majority of the members of the Executive Board in attendance at a regular or special meeting and provided further that final votes will not be counted until fourteen days have elapsed from the time of mailing the ballots.

Article X

The latest edition of Robert's Rules of Order shall be followed in all meetings of the Society on points of procedure that are not specifically covered by these By-Laws.

Mohawk Automatic Slasher Saw

The Machine That All Sawmill Men Have Been Waiting For!

Proven in hardwood mills. An exclusive feature of this machine is the holdown which applies pressure to the slabs and edgings being cut before saw starts . . . and releases after saw clears the work. Plus . . . numerous other new features.

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FPRS News-Digest, Continued

SOCIETY NEWS

(Continued from page 19-A)

Eastern Canadian Section Establishes Student Awards

The Royal York Hotel, Toronto, has been selected as the site for the 1956 Annual Meeting of the Eastern Canadian Section of FPRS. The meeting will be held March 1 and 2.

The Section Executive Committee voted at a recent meeting to make four annual awards to undergraduate students in forestry, engineering, and/or architecture at various Canadian universities for the best technical papers in the forest products field. The papers may be part of individual course requirements or may be written specially for this competition.

Two first prizes of $50 each and two second prizes of $25 each will be presented for winning papers by forestry students and winning papers by architecture and/or engineering students. The prizes will be awarded at the Annual Meeting in March.

FPRS lapel pins will be presented by the Section to all members attending the Annual Meeting, it was announced following the Executive Committee meeting.

"DIFFUSION BOARD" to filter out poisonous gases is shown by Dr. A. J. Stamm of U. S. Forest Products Laboratory.

Board to Filter Poison Gas Developed at Forest Products Lab

A cheap wood-fiber building board that filters poison gas, disease-laden particles, and the radioactive fall-out of atomic explosions from the atmosphere has been developed by the U. S. Forest Products Laboratory under a contract with the Army Chemical Corps.

With the new material, shelters can be built to protect troops and civilians from some of the most deadly effects of modern war, predicts Dr. J. A. Hall, Laboratory director. Present small-scale commercial production of the material, called "diffusion board" is for military testing purposes.

Developers of the new fiberboard are Drs. Alfred J. Stamm and Harold Tarkow of the Laboratory. Both are members of the division of wood chemistry, headed by Dr. Edward C. Locke.

The diffusion board looks much like ordinary building fiberboards. Secret chemicals in the material screen out deadly gases and particles, but oxygen passes through it so that persons in shelters won't suffocate, Dr. Stamm said. Likewise, carbon dioxide given off in breathing and respiratory vapors can pass through the material.

Any species of wood can be pulped to make the material, it is reported. Pilot-scale production tests have shown that the fiberboard can be manufactured with much of the same equipment used in making ordinary building fiberboards.

Fire Resistivity of Wood Studied by Canadian Institute

A long range program of research into the fire resistance of building materials has been started by the Canadian Institute of Timber Construction. Hugh E. Thompson of Ottawa, a FPRS member and graduate engineer, is heading the project.

First step in the program will be a survey of literature, to be followed by actual tests of building components. The knowledge gained will apply particularly in two fields: building codes and other regulations governing the use of materials, and fixing insurance rates. The project's goal is to bring better knowledge of wood's fire resistivity to builders, code specialists and insurance men.

"Timber is a good heat insulator," Thompson points out, "and large members retain their strength and form under high temperatures." Insurance and code specialists agree that heavy timber is a good fire risk, he adds, but they are unable to make full use of wood's characteristics because of a lack of scientific data.

PROFESSIONAL CARD

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INDUSTRIAL PLANT ENGINEER
Specialist in
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NLMA MONTHLY STATISTICAL REPORT—AUGUST 1955 LUMBER AND HARDWOOD FLOORING

(Estimated Industry Totals)

Reported Totals Adjusted to 100% Basis

Regions:	August, 1955 Production	Shipments	Orders Received	August 31, 1955 Unfilled Orders	Gross Stocks
	(Thousand Board Feet)				
SOFTWOODS:					
Southern Pine	750,000	797,000	794,000	285,000	1,670,000
Douglas Fir	849,278	772,256	714,597	761,584	803,754
Western Pine	959,153	908,620	999,997	715,237	1,646,000
Redwood Region	264,000	274,000	268,000	136,000	410,000
Other Softwoods	215,944	210,546	212,437	272,891	422,398
TOTAL SOFTWOODS	3,038,375	2,962,422	2,989,031	2,170,712	4,952,152
% Change from July, 1955	+23.3%	+14.3%	+ 9.4%	+ 1.3%	+ 1.6%
% Change from August, 1954	+31.1%	+22.9%	+26.4%	+ 3.5%	— 4.1%
HARDWOODS:					
Southern Hardwoods	326,000	373,000	374,000	223,000	2,194,000
Other Hardwoods	288,191	329,739	330,623	187,884	1,311,452
TOTAL HARDWOODS	614,191	702,739	704,623	410,884	3,505,452
% Change from July, 1955	+ 6.4%	+ 9.7%	+ 2.2%	+ 0.5%	— 2.5%
% Change from August, 1954	— 3.9%	+26.0%	+22.0%	+49.5%	—10.3%
TOTAL LUMBER	3,652,566	3,665,161	3,693,654	2,581,596	8,457,604
% Change from July, 1955	+20.2%	+13.4%	+ 7.9%	+ 1.1%	— 0.1%
% Change from August, 1954	+23.6%	+23.4%	+25.6%	+ 8.9%	— 6.7%
FLOORING:					
Oak Flooring	109,306	108,070	105,632	99,403	44,424
Maple Flooring	4,850	5,425	5,550	15,475	8,000

COMPARISONS FOR EIGHT MONTHS, YEAR-TO-DATE, 1954 AND 1955

	Production	Shipments	Orders Received
	(Million Board Feet)		
SOFTWOODS:			
January–August, 1954	18,879	19,497	20,036
January–August, 1955	21,271	21,594	21,968
1955 % Change from 1954	+12.7%	+10.8%	+ 9.6%
HARDWOODS:			
January–August, 1954	4,953	4,297	4,278
January–August, 1955	4,855	5,316	5,516
1955 % Change from 1954	2.0%	+23.7%	+28.9%
TOTAL LUMBER:			
January–August, 1954	23,832	23,794	24,314
January–August, 1955	26,126	26,910	27,484
1955 % Change from 1954	+ 9.6%	+13.1%	+13.0%

MEREEN-JOHNSON NO. 441A *New*

extra heavy duty GANG RIP SAW

MEREEN-JOHNSON has manufactured gang rip saws for 40 years. Power, speed and accuracy have always characterized M-J machines. This new No. 441A has all the features of previous models, with some important new ones added.

- Now *eight power-driven feed rolls*—two pair infeed and two outfeed. This is a double safeguard where utmost accuracy of production is required.
- 7200 RPM arbor speed puts extra power where it's needed.
- Vertical arbor adjustment simplifies bed plate removal.

If your production includes sheet materials, hardwood flooring, furniture core stock or wirebound boxes—it will pay you to investigate this big, rugged M-J No. 441A Rip Saw.

ONE-PIECE ARBOR BEAM

Exclusive with M-J is this beam mounting of motor, arbor and bearings in a single rigid unit.

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TENONERS	VENEER & PLYWOOD SIZERS & JOINTERS		RESAWS

Send For The No. 441A Bulletin

Holding Cost Line Underlying Theme of NAFM Convention

Intense interest in holding the cost line in the face of rising prices and competition was largely responsible for the success of the furniture industry's first Supply, Equipment, and Fabric Fair, according to John M. Snow, executive secretary of the National Assoc. of Furniture Manufacturers. The fair was held in conjunction with the 27th annual NAFM convention in Chicago August 28–Sept. 1.

More than 1700 persons from the woodworking and furniture industries attended the Fair, eight times the attendance at past NAFM conventions. Enthusiasm for the fair carried over into the convention, Snow reported, with standing room only in many sessions.

Products including saws, glues, machinery, and surfacings were shown by 120 suppliers and exhibitors. FPRS had an educational display designed to stimulate interest in furniture industry research and development. The Society demonstrated actual working samples of some common wood technology problems facing the furniture industry and their best known solutions.

The entire lumber industry was scooped by the Great Eastern Lumber Co., Glens Falls, N. Y., the only regular lumber concern exhibiting at the Fair. Nelson Nash, Sales Manager, was in charge of the exhibit and reported wide interest among visitors. Great Eastern's display consisted of a large mural of their facilities, forests, sawmills, and kilns, and samples of birch, maple, beech, oak, etc., to demonstrate the quality and texture of Northeastern hardwoods.

During the NAFM convention, more than 20 experts from all fields of business administration, sales management, labor relations, research, and production warned manufacturers against being complacent in times of rising sales and falling profits. Although production may double in the next ten years, manufacturers must put added effort into training sales people and providing tested selling aids on the retail level, Snow said.

K. KROEHLER

New officers and directors for the coming year were elected during the convention. Kenneth Kroehler, vice-president of Kroehler Manufacturing Co., Naperville, Ill., was named president to succeed Clyne Crawford, president of Crawford Furniture Manufacturing Corp., Jamestown, N. Y.

Awards for outstanding safety records were presented to 19 member plants of NAFM, with seven plants receiving the award for the second consecutive year.

"Furniture manufacturers could increase their market at least 65 per cent over present levels by 1960," the convention was told by Arno Johnson, vice-president and director of research for J. Walter Thompson Co. His analysis of the huge new market is based on the rapid increase in the number of U. S. families, the trend to larger families, and the fact that these families are constantly climbing upward in income level.

New Look at Wood

"Let's Take A New Look at Wood as a Raw Material," was the topic of an address by C. D. Dosker, Gamble Bros., Louisville, Ky. The furniture industry represents an important segment of the forest products industry, using 1.5 billion board feet of hardwood lumber annually or about 20 per cent of total hardwood lumber production, he said.

"Wood is a basic raw material. Because it is a commonplace raw material, few people realize its importance in the nation's economy and to national defense," Dosker pointed out. "In World War II, wood was second only to steel in tonnage needed for defense purposes. Timber is this nation's greatest renewable resource and will be available long after ore deposits are gone.

"In your great industry, you think of wood generally in terms of board lumber and veneer, and their end product, furniture. You do not think of wood in terms of the paper on which your advertising is displayed, its importance in record-keeping, the cartons in which your products are shipped, the synthetic fibers that reinforce the tires of your cars and trucks.

"From wood, such products as wood molasses, a feed for cattle, is manufactured. Wood can be used as a gas for driving motor cars. From wood, such products as alcohol and many essential oils can be produced. We have only seen the beginning of the products available from wood.

"In terms of wood's availability, we in this country are finding that merchantable timber on a sustained yield basis will grow on land not suited for other use. For all purposes, today, for the first time in 50 years, growth and drain on our timber resources are in balance. If fire and disease of trees

TECO Scholarship Winners Complete Training

TESTING BENDING STRENGTH of particle board are four graduate wood technologists, winners of the NLMA-sponsored scholarships for special training at Timber Engineering Co. They are: (left to right) H. A. Huber, a FPRS student member, U. of Michigan; K. A. Wanner, Montana State U.; D. C. Markstrom, U. of Minnesota; and T. J. Patterson, a FPRS student member, Oregon State. The men completed ten weeks' training in wood research at the TECO laboratory last month.

New Equipment and Methods Demonstrated at NAFM Fair

C. D. Dosker, president of Gamble Brothers, urged a new look at wood as a raw material at NAFM convention. Listeners included Clyne Crawford (left), retiring NAFM president.

FPRS booth was visited by L. E. Jahn and V. E. Noltemeyer, Gamble Brothers, shown with Frank J. Rovsek, Executive Secretary, and Ed Roche, Editor.

Austrian Visitor, Alois Kohl (left), Petri & Co., Vienna, discussed gluing techniques with E. C. Dorsa, National Adhesives.

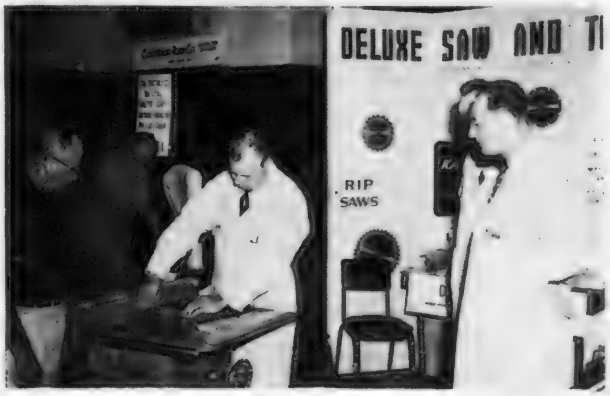
Profits and Progress from Research was theme of New York College of Forestry exhibit. Dr. Harold B. Gatslick (right) explains program to Frank Hemingway (left), Jamestown Furniture Manufacturers Assoc., and David H. Crawford, Crawford Furniture Manufacturing Corp.

O. B. Mitchell and Roland Lundberg of Henry Disston & Sons staffed their firm's exhibit.

Glue strength is demonstrated to F. J. Rovsek, FPRS Executive Secretary, by C. S. Young and S. E. Carroll of Swift Adhesives.

Chipcore is subject of discussion by M. H. Kruissink, Morgan Mfg. Co., and W. J. Wittendorf and C. W. Hazel of Dean Co.

Lumber industry was scooped by Great Eastern Lumber Co., only regular lumber firm exhibiting at Fair. Seated is Nelson Nash, Great Eastern Sales Manager.



Robert L. Ford of Deluxe Saw and Tool Co. demonstrates saw to B. E. Friedlander, Spotnails, Inc., while R. A. Baudendistel and Albert Oehl of Deluxe look on.

FPRS News-Digest, Continued

could be completely controlled, new growth would exceed drain.

Another point discussed was that many of the so-called defects and blemishes in wood are a part of its natural beauty. The configuration of the grain around these defects adds to the charm and appeal of wood. "If the furniture industry takes advantage of this beauty and appeal, it will at the same time reduce its raw material cost by its ability to use a higher proportion of the lower grades. In addition, individualistic touches can be provided for each suite when character marked lumber is used.

Impact of Research

"A transition is taking place in the forest products industries. Its beginnings have been slow, but research is making its impact felt and accelerating this transition. New and less wasteful methods of conversion are being developed, but there needs to be more consolidation at points of primary conversion.

"Also, wood processors today need technically trained people who know wood as a raw material, know the chemistry of adhesives, and know mechanics to understand modern equipment. This technician might be called a 'wood-techno-chemico-mechanical engineer'."

He traced the decline in per capita consumption of hardwood lumber, from 116 board feet in 1900 to 51 board feet in 1950, and compared this decline with the increase in use of competitive materials. These figures indicate a lack of progress in the lumber industry, he asserted.

"In 1952, it is estimated, $26 million was spent for research in the forest products industry. Of this amount, about $20 million was spent by the pulp and paper industry, leaving only $6 million spent for the improvement of knowledge and know-how by the entire remainder of the wood-using industries.

In conclusion, Mr. Dosker urged his listeners to "think of things you can do with wood. Dream of the things you have not yet done with it. Modernize your thinking about wood in terms of laminates, in terms of wood products on which adequate information is available, in terms of a stabilized material, in terms of burn-proof and alcohol-proof finishes, in regard to machinery needs, in terms of your processes."

Bruce Named Speaker for Illinois Pilot Plant Dedication

C. Arthur Bruce, executive vice-president of E. L. Bruce Co., Memphis, Tenn., will be principal speaker at the dedication of the new Wood Products Pilot Plant at Southern Illinois University's Vocational Technical Institute, near Carbondale, Ill. The pilot plant will be dedicated in ceremonies scheduled to begin at 10 a.m. Saturday, November 12.

The morning program will consist of dedication activities and introduction of guests and officials. A barbecue lunch will be served at noon and in the afternoon guests will be conducted on tours of the plant.

The pilot plant is part of the cooperative forestry program between Southern Illinois U. and the Carbondale Forest Research Center, Central States Forest Experiment Station, U. S. Forest Service. It is being equipped with modern production-type woodworking machinery, automatic conveyors, air-drying yard, small dry-kiln, and supplementary units for use in the training and research program.

The new training center and research laboratory will provide facilities for training students in the operation and maintenance of woodworking equipment, modern production methods, handling and processing lumber

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FOR
DRY-FORMED PARTICLE BOARD
(Splinter and Flake Types)

SURVEYS, DESIGNS, PRODUCT SPECIFICATIONS
MACHINERY AND EQUIPMENT
ENGINEERING STAFF, LABORATORY
AND
EXPERIMENTAL PLANT FACILITIES

INSTALLATIONS IN
OPERATION PROVE THE VALUE
OF THIS SYSTEM
OF
WOOD UTILIZATION

MILLER HOFFT, INC.
RICHMOND 26, VIRGINIA

Do you have a production problem with FEEDING—OR GLUING?

SARANAC offers an unusual proposition:

In developing the famous high-production Saranac CR Machine, two problems were encountered. These were the designing of (1) automatic feeding and (2) automatic gluing devices.

Saranac engineers solved these problems with designs that have since proved tremendously successful in operation in customers' plants.

Now—because these automatic devices have countless other application possibilities throughout Industry, we are offering them for your consideration. They can be adapted to many types of existing equipment, or included as components of new production machines you may be planning.

Their outstanding features are described here. Can *you* put them to work to mechanize your operations, speed production and cut costs?

Saranac AUTOMATIC GLUE APPLICATOR

Electro-magnetically controlled

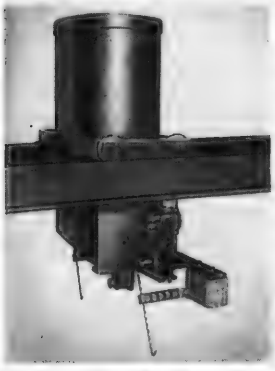


Fig. 3228

This unit automatically meters and applies glue, in precisely controlled thin strips, onto parts or materials which pass beneath it. From the fountain, glue passes through the highly successful new Saranac Rotary Glue Valve or Valves.

In operation, the leading edge of work material contacts the Control Lever extending from bottom of unit (Fig. 3228). This lever actuates a Micro-Switch which then energizes the Electro-Magnetic Solenoid that opens Rotary Glue Valve. When trailing edge of work material reaches the Control Lever, the Solenoid closes valve, instantly stopping the flow of glue.

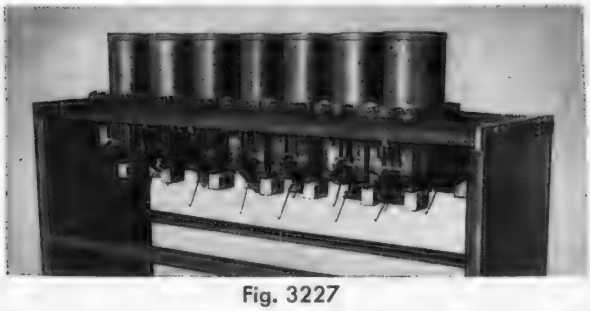


Fig. 3227

These highly adaptable Glue Applicators are adjustable *horizontally,* for desired location of glue strips across width of material . . . *longitudinally* for starting or stopping flow of glue exactly where wanted . . . and to *regulate volume* of glue flow to proper, economical amount.

Glue Applicator and Fountain can be furnished with single or double Rotary Valve. Whole batteries of Applicators can be used if the job requires (Fig. 3227).

AUTOMATIC CHAIN-FEED CONVEYOR

Electro-magnetically controlled

This Chain Feeding and Conveying Device has well proved its efficiency for feeding parts into Saranac Fastening Machines. Versatile in application, it is easily adapted for feeding many types of parts and sheet materials through automated production processing or assembly lines.

A complete chain feeding deck includes two or more rails like the single cross section shown (Fig. 1450). Operating advantages are: Materials in process move at constant speed *while in motion,* but are *instantly stopped* while processing operation (stapling, drilling, spot welding, assembly, etc.) takes place. Chain dogs which move materials are easily adjusted to change set-up for different spacing or size of conveyed pieces.

For volume production, automatic work stops, hopper-feeds for materials and other accessories may be adapted to some applications.

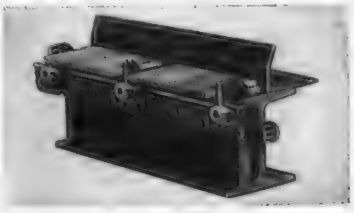
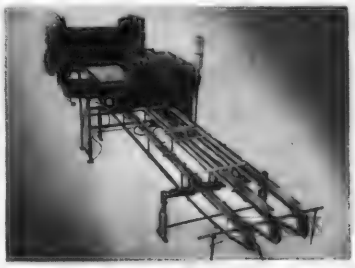


Fig. 1450

WHAT IS YOUR PROBLEM?

This high-production Saranac CR Machine includes both the Chain Feed Conveyor and Automatic Glue Applicators. Can you too cut costs by adapting these units to your production machines?



Write Saranac, describing your application. Our engineers will offer helpful assistance.

SARANAC MACHINE COMPANY

BENTON HARBOR • MICHIGAN

Manufacturers of the World's Largest Line of Fastening Machinery

FPRS News-Digest, Continued

DEBARKING PROBLEMS were discussed by representatives of pulpwood industry in meeting at Battelle Institute. M. R. Nestor (standing, left) of Battelle, led the discussion organized by W. C. Finley (standing, right), Battelle's wood industry liaison representative.

and similar materials related to the commercial manufacture of wood products.

Battelle Institute Sponsors Conference on Debarking Problems

Debarking problems of the pulpwood industry were discussed at an all-day meeting Sept. 14 at Battelle Institute, Columbus, Ohio. Representatives of 20 pulpwood firms from 10 states participated.

The discussions pointed out that net domestic requirements for pulpwood in the U. S. will increase from the present 28.5 million cords to 47.5 million in 1975. It has been predicted that pulpwood requirements in the South will double in the next 20 years to approximately 30 million cords.

The group analyzed research approaches to the problems of removing bark from slabs, edgings, chips, and other residues. Present debarking methods were reviewed, and possibilities discussed for utilizing hardwoods in pulping processes.

Lumberman Nash Scores Solid Smash, Briefs Poet Ogden On Use of Ash

Nelson Nash, Sales Manager for Great Eastern Lbr. Co., Glens Falls, N. Y., and former president of the Adirondack Lumbermen's Assoc., has a reputation for alertness and being always ready to aid in proper lumber utilization. Now he has scored a solid hit in the Letters-to-the-Editor columns of LIFE magazine.

In the Sept. 5 issue, LIFE featured several amusing poems on baseball stars by famous poet Ogden Nash. In one of these, Poet Nash intimated that Cal Abrams used a hickory baseball bat. LIFE published the following letter from Mr. Nash, the lumberman, in the Sept. 26 issue.

Sirs:

True, Hickory
Rhymes with terpsichore.
But it won't do Cal Abrams batting average any good
Using the wrong wood.
Please tell him quickly, Mr. Ogden Nash,
Baseball bats are made of ASH.

signed: Nelson (no relation to Ogden) Nash

To which Poet Nash replied:

Batters, be thankful this rhyme—employer
Didn't need one for sequoia.

LAUCKS Sentry
PAT. APPLIED FOR

Gives 100% inspection of moving veneer, lumber, core and dimensional stock, paper, fibreboard and related products. Automatically rejects any material outside the proper moisture limit. Eliminates poor glue bonds, warpage, splits, dimensional change and other moisture-induced "fall-downs." Dryer schedules may be adjusted to peak performance. A production line machine, Laucks SENTRY® gives continuous and highly accurate control—permits safe speed-ups through entire production cycle. Write TODAY for free brochure.

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1201 Poplar Place Seattle 44, Washington
A LEADER IN WOOD TECHNOLOGY FOR 47 YEARS

For a *truly* good floor

NORTHERN HARD MAPLE

truly economical

truly modern

truly resilient

★

MAPLE FLOORING MANUFACTURERS ASSN.
CHICAGO 1, ILLINOIS

AFTER THE AX
WE S-T-R-E-T-C-H THE TREE

And help to make America's forests last longer, yield more.

Through an extensive research and development program, United States Plywood Corporation is helping to meet today's tremendous demand for wood products.

Today, we use more of *every* tree for plywood, lumber and a growing list of new wood products, such as Novoply®.

Through sales promotion and advertising, we are vigorously developing new markets and wider usage of wood products that once had only limited commercial value.

Recently the United States Plywood Corporation announced the further expansion of its research facilities with the acquisition of a tract of land as the site for the Lawrence Ottinger Research & Development Center.

Only through such programs as these can more and more people continue to enjoy the unmatched beauty, utility and economy of wood.

Weldwood

UNITED STATES PLYWOOD CORPORATION

WELDWOOD—The Best Known Name in Plywood

FPRS News-Digest, Continued

NAMES IN THE NEWS

Clark C. Heritage Retires; Continuing Career as Consultant

C. C. HERITAGE

Clark C. Heritage, who has devoted more than 40 years to forest products and chemical developments, retired October 1 as Weyerhaeuser Timber Co.'s development director. Heritage, a registered professional chemical engineer, is establishing an office in Tacoma, Wash., to serve industry in the establishment, planning and execution of research and development programs.

Dr. Winton I. Patnode, formerly a research chemist and administrator at General Electric Co., succeeds Heritage as research director at Weyerhaeuser.

During his 18 years with Weyerhaeuser and its former subsidiary, Wood Conversion Co., Heritage pioneered in uses of whole-wood fiber in felts, boards and contoured articles. He has contributed to the development of new products and processes in the fields of lumber, pulp, paper and paperboard, organic chemicals, and dyestuffs.

Heritage attended the U. of Chicago and received a degree in chemical engineering from Armour Institute of Technology in 1914. Before joining Weyerhaeuser, Heritage was associated with Nekoosa Edwards Paper Co., National Aniline & Chemical Co., Cornell Wood Products Co., U. S. Forest Products Lab, and Oxford Paper Co. In 1937, Heritage joined Wood Conversion Co., and in 1950 he became Weyerhaeuser's director of development.

Heritage, a charter member of FPRS, is a former president of the Technical Association of the Pulp and Paper Industry.

Finland Engineer Studying at Forest Products Lab

Dr. Eero Kivimaa, research engineer at the State Institute for Technical Research and lecturer at the Institute of Technology, Helsinki, Finland, has been awarded an ASLA–Fulbright research scholarship for 10 months' study at the U. S. Forest Products Laboratory, Madison, Wis.

Kivimaa plans to study cutting life of woodworking tools and its dependence on such factors as cutting speed, quality, and species of wood. He is also interested in veneer cutting and wood machining problems.

Author of several publications on wood machining, Kivimaa holds M. Sc. and Dr. of Technology degrees from the Finland Institute of Technology.

J. R. Stillinger Named Technical Director of Firm

J. R. STILLINGER

John R. Stillinger, FPRS Pacific Northwest Section Vice-Chairman, has been appointed technical director for the Lebanite Products Division of Cascades Plywood Corp., Lebanon, Ore. Stillinger had been research co-ordinator at the Oregon Forest Products Lab, Corvallis, since 1948.

In his new position, Stillinger is in charge of development of new products of Lebanite, a dry process board, and will be responsible for quality control.

A graduate of the U. of Idaho Forestry School, Stillinger received M. S.

The OLIVER is built right to insure smoothest planing

Gives you 40 feet a minute of level, low-cost surfacing

This popular Oliver Surfacer takes stock up to 24" wide, 8" thick. It feeds stock at any rate from 18' to 40' a minute at the turn of a dial. Controls are centrally located for operator's convenience. Has built-in jointing and grinding rigs. Precision built to assure rigidity and permanent alignment of moving parts. Write for Bulletin No. 299-D.

OLIVER MACHINERY COMPANY

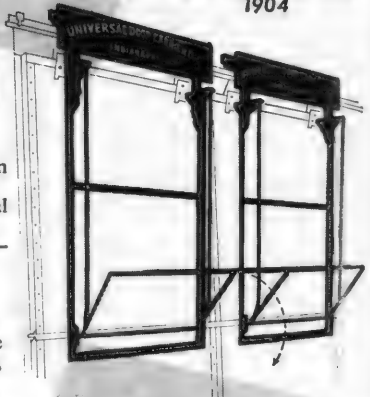
Since 1890 — GRAND RAPIDS 2, MICH.

Universal TIME-PROVEN **DOOR CARRIERS**

The Original "DRY KILN DOOR CARRIER" *Famous The World Over Since 1904*

For Fast, One Man Operation of Dry Kiln Doors

Yes, *one man* can easily open or close a kiln in a few seconds!—using a Universal Door Carrier. And, good tight closures—every time—are assured by *automatic cam-action locks*. What's more—your *doors* last longer, because the Carrier saves them from destructive bending, twisting, straining, and slamming. As for durability of the Universal equipment itself, some of our *first* "Dry Kiln Door Carriers" are still in regular use after *a half-century of service*. Let our factory representative give you full details—without obligation.



OUR EXCLUSIVE LINE INCLUDES:
Doors—Carriers—Parts. (1) The perfected original "Dry Kiln Door Carrier"; (2) The best, insulated all-metal kiln doors ever built—bar none! (3) Genuine factory replacement parts.

Universal DOOR CARRIER, INC. 1117 CORNELL INDIANAPOLIS

Specialists in Kiln Closure Equipment — Since 1904

LOVSTED'S DRY KILNS ARE THE MOST EFFICIENT IN OPERATION TODAY

NORTH COAST "DIRECT-FLO" DRY KILNS

WHATEVER the specific problem of lumber seasoning, there's a solution in some type of Lovsted "DIRECT-FLO" Kiln. These units are without question the most efficient kilns in operation today. They embody such specialized features as reversible circulation with fans positioned to create uniform drying with lowest possible power input per cubic foot of air produced. Look to the engineers of C. M. Lovsted & Co., Inc. to bring your own lumber seasoning to efficient operation.

PROFITS AHEAD WITH LOVSTED

TOOTS-E WHISTLES

We manufacture a complete line of air and steam whistles ranging in size from our small *TOOTS-E Whistle*, used for coding calls, to the large Mill Whistles.

The TOOTS-E Jr. (7 lbs.) has a shrill tone that can be heard over other mill noise and makes the ideal call system. Its operation is as snappy as a telegraph key. It is air operated and electrically controlled by push button.

The large mill whistles are made for either air or steam and either is electrically controlled by push button.

We also manufacture fire alarm whistles.

Send for our illustrated catalog FP.

C. M. LOVSTED & CO., Inc.

ENGINEERS & MANUFACTURERS

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FPRS News-Digest, Continued

NAMES IN THE NEWS

and Ph.D. degrees from the New York State College of Forestry.

R. M. Garratt Joins Teco Laboratory Staff

Rowland M. Garratt, graduate engineer of Massachusetts Institute of Technology, has joined the laboratory staff of Timber Engineering Co., Washington, D. C., according to Carl A. Rishell, director of research. Gar-

R. M. GARRATT

N. GONZALEZ

ratt will visit lumber producing plants, wood product manufacturers, and the wood using and processing industries generally, to assist them in product and process development and improvement. Formerly product development engineer with Gamble Brothers, Inc., Louisville, Ky., Garratt served as Secretary and Chairman of the Ohio Valley Section of FPRS. He is a son of Dr. George A. Garratt, past president of FPRS and dean of the Yale School of Forestry.

Garratt holds a B.S. degree in building engineering from M. I. T. He later attended Yale School of Forestry, where he specialized in wood technology.

Gonzalez Named Research Director by Pencil Manufacturer

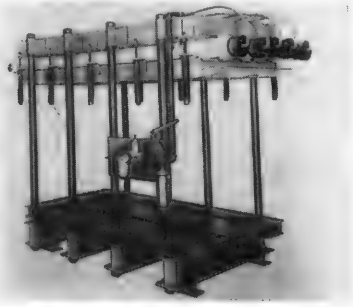
Dr. Narciso Gonzalez, a FPRS member, was recently appointed Director of Research for the Eagle Pencil Company, 703 East 13th St., New York, N. Y. Dr. Gonzalez, former Director of Quality Control for the company, succeeds the late Mr. I. Chesler.

NEW PRODUCTS—LITERATURE

Laminating Press

A new type of laminating press is announced by Black Brothers for use in the fabrication of hollow core flush doors, plastic faced table and counter tops, and many other laminating operations.

Air pressure introduced into several units of closely spaced, special oversize hose, located above the upper movable



platen, actuates the press through the expansion and contraction of the hose.

Loading of the Air Hose press is expedited through the use of spring type roller loaders consisting of two tracks with closely spaced rollers. Springs hold the top of the rollers above the lower platen, permitting the package to roll into and out of the press. Platen sizes range from 30 by 30 inches to 50 by 120 inches. Further information is available from Black Brothers Company, Inc., Mendota, Ill.

Monthly Executive Bulletin

Publication of the new National Casein Executive Review has been announced. Each issue will contain articles from well-known magazines of interest to executives, an educational article on glue room helps, and a personality profile of plant personnel.

Copies of the new publication are available on request from Dept. ER-27, National Casein, 601 W. 80th St., Chicago.

New Log Debarker

A log debarker that will handle timber from 2 to 14 inches in diameter at a speed of 150 feet per minute has been introduced by Soderhamn Machine Manufacturing Co., Talladega, Ala.

Known as the Cambio Barker, the device is reportedly equally efficient on hardwoods and softwoods. Special demonstrations held recently were attended by many of the nation's leading timber mill operators.

Preservative Plant

A new plant at Merrill, Wis., for the production of Penta-WR, water repellent wood preservative, has been announced by Chapman Chemical Co., Memphis, Tenn. President A. Dale Chapman revealed the company also has opened Penta-WR production facilities at Houston, Texas, and Richmond, Calif.

This expansion of the firm's production facilities has several advantages for millwork plants, it was pointed out. Savings through increased production and lower freight charges, 24-hour delivery enabling smaller preservative inventories, are among benefits to users.

Waterproof Adhesive

Faster production of waterproof, laminated, or corrugated boxboard, paper tubes, and bags is possible with a new waterproof adhesive developed by Koppers Co., Inc. Previous materials have not permitted high-speed corrugated board production, it is reported.

Plant Expansion

Construction has begun on additional factory and manufacturing facilities at the suburban Minneapolis plant of Timesavers, Inc. The facilities will be used to increase production of the Timesaver shapesander and speedsander machine, reports R. J. Pendergast, president.

Kiln-Drying Course Given in Florida

Faster drying, reduction of defects, and precise methods of dry kiln operation were discussed at recent Kiln-Drying Short Course at U. of Florida, Gainesville. Participants were, left to right, front row: L. F. Rand, J. H. Sterling, T. R. McClain, W. R. Smith, C. M. Kaufman, E. F. Rasmussen, A. E. Sanders, J. Powell; back row: M. A. Taras, B. M. Witherow, J. O. Tilghman, D. K. Post, T. P. McLaughlin, S. S. Bridges, J. B. Huffman, W, Carter, L. J. Hebert, J. L. Orr, R. L. Fairing, O. C. Heyer.

Your Profits will add up FAST

when you erase High Production Costs

BY INSTALLING A VENEER CLIPPER THAT IS MATCHED TO YOUR PRODUCTION REQUIREMENTS

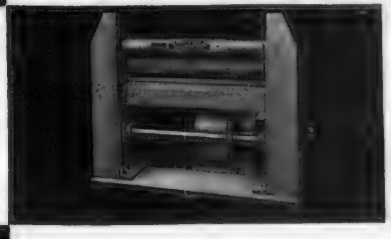
When your veneer clipper matches your production line requirements and provides dependable, continuous performance you can enjoy a greater margin of profit.

This is the reason Merritt-Solem builds three models of clippers, one of which will meet your production requirements with minimum capital investment and provide the continuous performance necessary to maintain a steady flow of profits.

Besides the standard clippers described, Merritt-Solem offers custom-built clippers to meet the unusual requirements.

Write Merritt-Solem for complete information.

Model C-530-M Clipper for general production clipping. All Merritt-Solem Clippers feature magnetic driving action that eliminates adjustment and reduces wear on clutch members.



Model C-530-L with high speed knife action. For close-up work and as an added safety factor, all Merritt-Solem Clippers feature completely enclosed moving parts.

Model C-530-H Clipper . . . back geared for additional power. All Merritt-Solem Clippers have self aligning, heavy duty roller bearings to insure constant alignment of all moving parts and to reduce wear.

MERRITT-SOLEM

DIVISION OF SOLEM MACHINE COMPANY

124 S. NIAGARA ST., LOCKPORT, N. Y.

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

Booklet Describes Teco Facilities for Research

Key methods and equipment with which wood and wood products are tested and evaluated are depicted in a new publication, "Teco Testing

Facilities", issued by Timber Engineering Company, 1319—18th St., N.W., Washington 6, D. C.

Standard laboratory facilities, as well as specialized equipment developed by the Teco staff, are shown in action, testing new and improved wood products for their performance in strength, durability, stability, and utility value.

Sales Headquarters Moved

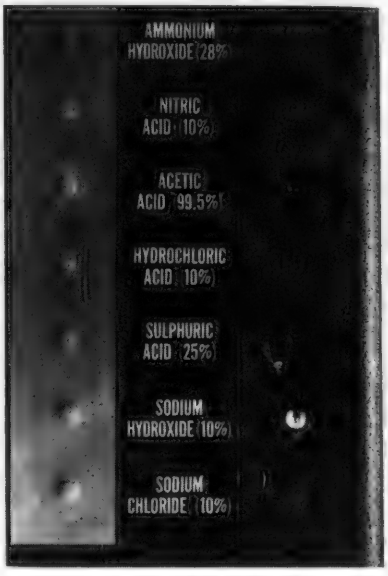
Sales headquarters of the flexible materials division of U. S. Plywood Corp. has been transferred to Louisville, Ky., according to W. H. Hunt, vice-president in charge of sales. This division's sales were previously supervised in the firm's New York office.

The move was made to coordinate more closely the sales and manufacture of Flexwood, flexible wood paneling for walls, and Kalistron, sheet plastic material used for walls, upholstery, and luggage. These materials are produced by U. S. Plywood in Louisville.

Rust Preventive Coating

Introduction of Uni-Coat rust preventive coating is announced by Universal Door Carrier, Inc., specialists in kiln closure equipment. Developed specifically to combat rust problems in dry kilns, the product is reported satisfactory for preventing corrosion of block racks, door frames, and other steel exposed to kiln conditions.

Containing a synthetic resin base, the coating is said to be tough, resilient, stable, and impermeable. The manufacturer reports it is unique in its resistance to water, steam, grease, and most solvents, acids, and alkalis. It is insoluble in gasoline, turpentine, or other ordinary solvents, sulphuric acid, or calcium chloride.



Comparative effects of corrosive substances on coated steel. Panel at left was coated with Uni-Coat rust preventive coating, panel at right with best competitive coating tested. Both panels were applied on a single sheet of steel, dented to provide test spots for corrosive liquids.

There is a reason why BILT-WELL WOOD WORK REG. U. S. PAT. OFF. ***is a leader!***

This is the modern plant where Bilt-Well Woodwork is "groomed" for its eventual role in the building programs being formulated today. Master craftsmen, research engineers and industrial designers pool their ideas to the scientific development of building products making it possible to produce a high standard of quality. The popularity of Bilt-Well Woodwork today stems from an enviable reputation built up in the past 89 years.

CARR, ADAMS & COLLIER COMPANY

Dubuque, Iowa

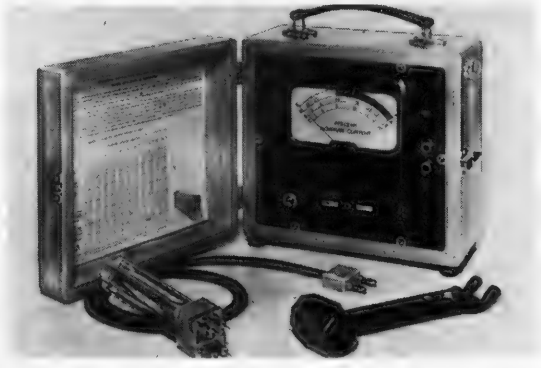
Manufacturers of the BILT-WELL Line of Outstanding Woodwork . . . BILT-WELL WINDOW UNITS—Awning, Double Hung, Casement, Basement, Storm and Screen, Gable Sash & Louvers . . . BILT-WELL CABINET UNITS—Kitchen, Wardrobe, Multi-Purpose, Corner China, Mantels . . . BILT-WELL DOORS—Interior, Exterior, Combination, Garage, Screen, Flush, Entrances.

KETCHIKAN SPRUCE MILLS

SITKA SPRUCE
WESTERN HEMLOCK

MILL AT
Ketchikan, Alaska

ALASKA YARDS
Anchorage
Fairbanks
Ketchikan
Palmer



The Delmhorst Moisture Detector

An inexpensive, easy-to-use instrument that quickly tells the moisture content of any wood species so that you can take immediate steps to prevent shrinkage, warpage and delamination before losses occur.

A complete descriptive bulletin concerning Delmhorst Moisture Detectors is available. Write for your copy. No charge or obligation, of course.

DELMHORST INSTRUMENT COMPANY
BOONTON 1, NEW JERSEY

New **Rockwell-built DELTA POWER FEED UNIT...**

... makes possible the LOWEST COST PRODUCTION RIPPING MACHINE on the market!

Delta's new Power Feed Unit is designed expressly for use with the rugged, versatile Delta 12" Tilting Arbor Saw. Together, this team gives you accurate, high-speed *production* ripping *at less cost* than most production table saws alone!

The new Delta Power Feed Unit is custom-engineered for *precision* . . . feeds accurately, insures straight cuts. For *speed* . . . selector dial control allows an infinite choice of speeds from 20 to 90 feet per minute. For *safety* . . . unit firmly grips stock after operator begins feeding.

It quickly swings down out of the way to give you full use of the versatile 12" tilting arbor saw for many extra jobs. *Your Delta Dealer is listed under "TOOLS" or "MACHINERY" in the classified pages of your phone book.*

DELTA ROCKWELL **DELTA** QUALITY POWER TOOLS

Another Product by **Rockwell**

DELTA QUALITY COSTS NO MORE

Send this Coupon for all the facts!

Delta Power Tool Division, Rockwell Manufacturing Company
700-K North Lexington Avenue, Pittsburgh 8, Pa.

☐ Please send me descriptive sheet on new Delta Power Feed Unit.
☐ Please send name of my nearest Delta Dealer who has both Delta Power Feed Unit and Delta 12" Tilting Arbor Saw on display.

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

FPRS News-Digest, Continued

Electric Sander

A new 24-inch single drum, endless bed sander is made by Woodworkers Tool Works, Inc., 222–224 S. Jefferson St., Chicago. The sander can be

fed stock up to 6-inches thick and will take pieces as short as 8-inches when fitted with an extra pressure bar.

Equipped with a 3-hp ACEC electric motor, the machine has a variable feed rate from 15 to 30 feet per minute. The non-oscillating drum reportedly sands hard or softwood smoothly without cross streaks.

NEW PUBLICATIONS

The Status of Wood Construction. E. G. Stern. Reprint from Applied Mechanics Reviews. Virginia Polytechnic Institute, Blacksburg, Va. Recent developments in the improved application of wood as a structural material are described in bibliographical survey of research and development which led to present status in various fields of wood construction.

Timbers of South East Asia. Gerald Hart. Timber Development Assoc. Ltd., 21 College Hill, London, E.C.4, England. Free. Contains descriptions of 40 timbers of interest in British market, with notes on their uses, properties, and working qualities.

The Source of Lumber for Furniture Plants in North Carolina. Walton R. Smith. N. C. Forestry Assoc., Inc., Raleigh, N. C.

Graduate Theses, 1944-54. State University of New York College of Forestry, Syracuse. Presents brief abstracts of all theses that have been accepted in partial fulfillment of requirements for advanced degrees at College of Forestry from 1944–54. Also includes appendix listing all theses accepted before 1944. Copies of the theses are available through interlibrary loan services.

Wood Columns, Design and Load Information. National Lumber Manufacturers Assoc., 1319 18th St. N.W., Washington 6, D. C. 50¢. Presents a new and simplified procedure for figuring how much weight can be supported safely by solid and laminated wood columns. New method is applicable to studs, compression members of trusses and other upright framing. Contains extensive tables of allowable loads for various sizes and lengths of wood columns, and detailed instructions on how to apply the information.

Facts about the Nation's Pulp, Paper and Paperboard Industry. American Forest Products Industries, Inc., 1816 N St. N. W., Washington 6, D. C.

Facts about the Nation's Lumber Industry, 1955. American Forest Products Industries, Inc., 1816 N St. N. W., Washington 6, D. C.

Pulpwood Industry Facts, 1955. American Forest Products Industries, Inc., 1816 N St. N. W., Washington 6, D. C.

DANT & RUSSELL, INC.

General Sales Offices:
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PACIFIC COAST FOREST PRODUCTS

RAIL AND CARGO

do you know all potentialities of wood residues?

CHEMICAL PROCESSING OF WOOD

By ALFRED J. STAMM, Ph. D.
Chief, Division of Derived Products
and ELWIN E. HARRIS, Ph. D.
Subject Matter Specialist in Wood Hydrolysis and Lignin Chemistry
Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wisconsin

CONTENTS

CHAPTER

1. Wood as a Chemical Raw Material.
2. The Constituents of Wood.
3. Structure of Wood.
4. Surface Properties of Wood.
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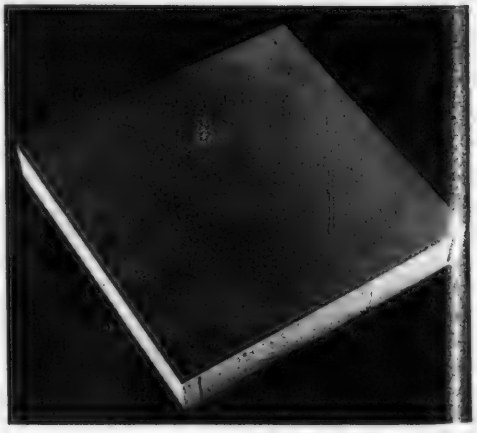

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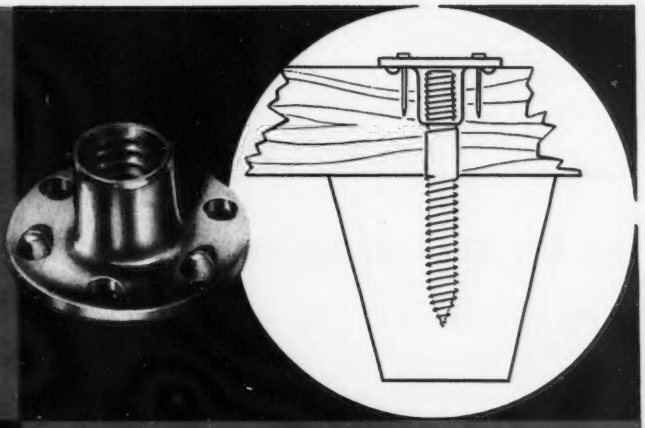

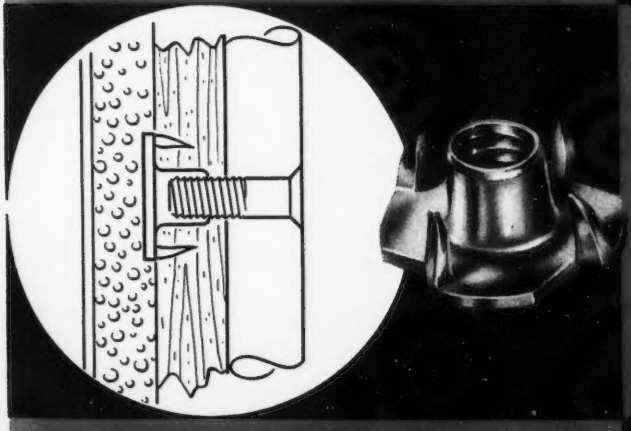

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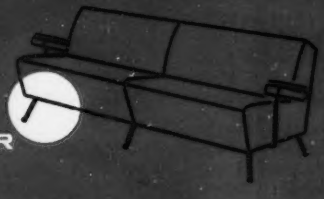

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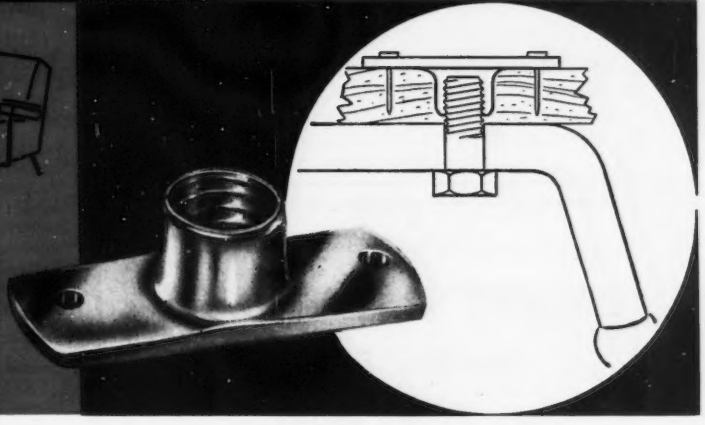

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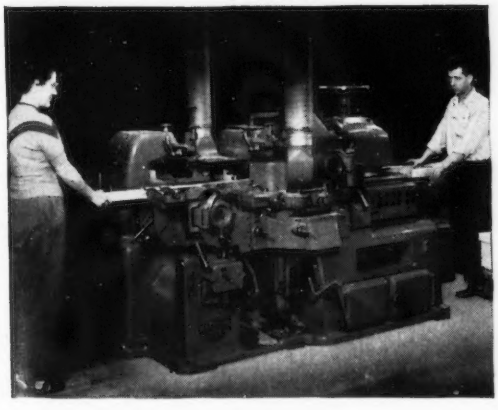

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A. F. Christy

A. F. Christy
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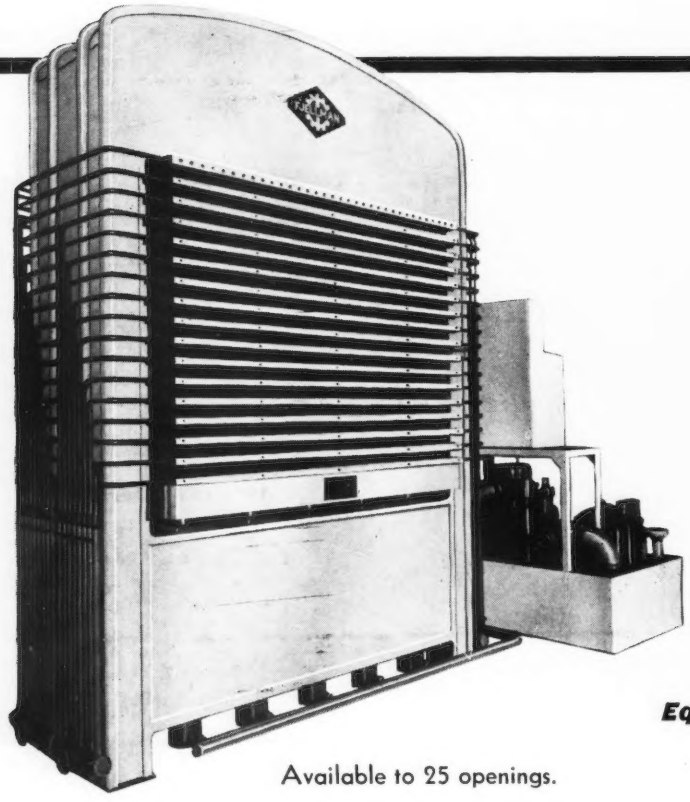

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